APPENDIX C
DEFINITION OF THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

APPENDIX C

DEFINITIONS OF THREATENED AND PRIORITY ECOLOGICAL COMMUNITIES

C1: Definitions of Threatened Ecological Communities

Presumed Totally Destroyed (PD)

An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B);

A) Records within the last 50 years have not been confirmed despite thorough searches or known or likely habitats or

B) All occurrences recorded within the last 50 years have since been destroyed.

Critically Endangered (CR)

An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii)

   i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 5 years)

   ii) modification throughout its range is continuing such that in the immediate future (within approximately 5 years) the community is unlikely to be capable of being substantially rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

   i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 5 years)

   ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes

   iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years)

Endangered (EN)

An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 70% and either or both of the following apply (i or ii)

   i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term (within approximately 10 years)
   ii) modification throughout its range is continuing such that in the short term future (within approximately 10 years) the community is unlikely to be capable of being substantially restored or rehabilitated.

B) Current distribution is limited, and one or more of the following apply (i, ii or iii):

   i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 10 years)
   ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes
   iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes

C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the short term future (within approximately 10 years).

Vulnerable (VU)

An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction in the medium to long term future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C):

A) The ecological community exists largely as modified occurrences which are likely to be capable of being substantially restored or rehabilitated.
B) The ecological community can be modified or destroyed and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations.

C) The ecological community may still be widespread but is believed likely to move into a category of higher threat in the medium to long term future because of existing or impending threatening processes.

Source: Department of Environment and Conservation (2010). *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*. Department of Environment and Conservation, Perth, Western Australia. Online: www.naturebase.net/

C2: Definitions of Priority Ecological Communities

Possible threatened ecological communities that do not meet survey criteria or that are not adequately defined are added to the Priority Ecological Community Lists under Priorities 1, 2 and 3. These three categories are ranked in order of priority for survey and/or definition of the community, and evaluation of conservation status, so that consideration can be given to their declaration as threatened ecological communities. Ecological Communities that are adequately known, and are rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list, are placed in Priority 4. These ecological communities require regular monitoring. Conservation Dependent ecological communities are placed in Priority 5.

Priority One: Poorly known ecological communities Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.

Priority Two: Poorly known ecological communities. Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation.

Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.

Priority Three: Poorly known ecological communities

(i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or:

(ii) Communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or;

(iii) Communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes.

Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.

Priority Four: Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring.

(a) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands.

(b) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

(c) Ecological communities that have been removed from the list of threatened communities during the past five years.

Priority Five: Conservation Dependent ecological communities. Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Source: Department of Environment and Conservation (2010). *Definitions, Categories and Criteria for Threatened and Priority Ecological Communities*. Department of Environment and Conservation, Perth, Western Australia. Online: www.naturebase.net/

APPENDIX D
ENVIRONMENTAL WEEDS AND DECLARED PLANT CATEGORIES

APPENDIX D

ENVIRONMENTAL WEEDS AND DECLARED PLANT CATEGORIES

D1: Criteria used for Ranking Environmental Weeds

The Environmental Weed Strategy for Western Australia (CALM 1999) contains criteria for the assessment and ranking of weeds in terms of their environmental impact on biodiversity. These criteria are as follows:

- Invasiveness – ability to invade bushland in good to excellent condition or ability to invade waterways. (Score as yes or no).
- Distribution – wide current or potential distribution including consideration of known history of wide spread distribution elsewhere in the world. (Score as yes or no).
- Environmental Impacts – ability to change the structure, composition and function of ecosystems. In particular an ability to form a monoculture in a vegetation community. (Score as yes or no).

The rating of each weed is determined by the following scoring system:

- High - a weed species would have to score yes for all three criteria. Rating a weed species as high would indicate prioritising this weed for control and/or research i.e. prioritising funding to it.
- Moderate -a weed species would have to score yes for two of the above criteria. Rating a weed species as moderate would indicate that control or research effort should be directed to it if funds are available, however it should be monitored (possibly a reasonably high level of monitoring).
- Mild – a weed species scoring one of the criteria. A mild rating would indicate monitoring of the weed and control where appropriate.
- Low – a weed species would score none of the criteria. A low ranking would mean that this species would require a low level of monitoring.

Source: Department of Conservation and Land Management (1999). *Environmental Weed Strategy for Western Australia*. Department of Conservation and Land Management, Perth, Western Australia.

D2: Standard Meanings of Declared Plant Categories

P1

Prohibits movement.

The movement of plants or their seeds is prohibited within the State.

This prohibits the movement of contaminated machinery and produce including livestock and fodder.

P2

Aim is to eradicate infestation.

Treat all plants to destroy and prevent propagation each year until no plants remain. The infested area must be managed in such a way that prevents the spread of seed or plant parts on or in livestock, fodder, grain, vehicles and/or machinery.

P3

Aims to control infestation by reducing area and/or density of infestation.

The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

Treat to destroy and prevent seed set all plants:

* Within 50m inside of the boundaries of the infestation;
* within 50m of roads and high water mark on waterways;
* within 50m of sheds, stock yards and houses.

Treatment must be done prior to seed set each year.

Properties with less than 20ha of infestation must treat the entire infestation.

Additional areas may be ordered to be treated.

P4

Aims to prevent infestation spreading beyond existing boundaries of infestation

The infested area must be managed in such a way that prevents the spread of seed or plant parts within and from the property on or in livestock, fodder, grain, vehicles and/or machinery.

Treat to destroy and prevent seed set all plants:

* within 50m inside of the boundaries of the infested property for one-leaf and 20m for two-leaf;

* within 50m of roads and high water mark on waterways;

* within 50m of sheds, stock yards and houses.

Treatment must be done prior to seed set each year. Properties with less than 20ha of infestation must treat the entire infestation.

Additional areas may be ordered to be treated.

Special considerations.

In the case of P4 infestations where they continue across property boundaries there is no requirement to treat the relevant part of the property boundaries as long as the boundaries of the infestation as a whole are treated. There must be agreement between neighbours in relation to the treatment of these areas.

P5

Aims to control infestations on public lands.

Source: Department of Agriculture and Food (2008). *List of Declared Plants*. Department of Agriculture and Food, Western Australia. Online: http://www.agric.wa.gov.au/.

APPENDIX E
BUSH FOREVER VEGETATION CONDITION SCALE

APPENDIX E

BUSH FOREVER VEGETATION CONDITION SCALE

Condition Scale Code	Condition Scale
P	Pristine (1) Pristine or nearly so, no obvious signs of disturbance
E	Excellent (2) Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
VG	Very Good (3) Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G	Good (4) Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	Degraded (5) Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	Completely Degraded (6) The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Bush Forever Vegetation Condition Scale as developed by Keighery (1994) and summarized in Bush Forever (Government of Western Australia (2000b)

APPENDIX F
FAUNA SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

APPENDIX F

F1: AMPHIBIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

AMPHIBIANS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
ANURA									
Hylidae									
Litoria moorei	Motorbike Frog				x				
Litoria adelaidensis	Slender Tree Frog				x				
Limnodynastidae									
Heleioporus barycragus	Hooting Frog				x				
Heleioporus eyrei	Moaning Frog				x				
Heleioporus psammophilus	Sand Frog				x				
Limnodynastes dorsalis	Western Banjo Frog				x				
Neobatrachus pelobatoides	Humming Frog				x				
Myobatrachidae									
Crinia pseudinsignifera	Bleating Froglet				x				
Crinia glauerti	Clicking Frog				x				
Crinia insignifera	Squelching Froglet				x				
Geocrinia leai	Ticking Frog				x				
Myobatrachus gouldii	Turtle Frog				x				

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F2: REPTILIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

REPTILES		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
SQUAMATA									
Diplodactylidae									
Crenadactylus ocellatus subsp. *ocellatus*	Clawless Gecko				x				
Diplodactylus granariensis	Western Stone Gecko				x				
Diplodactylus polyophthalmus	Speckled Stone Gecko				x				
Diplodactylus pulcher					x				
Nephurus milli	Barking Gecko				x				
Strophurus spinigerus	Soft Spiny-tailed Gecko				x				
Gekkonidae									
Christinus marmoratus	Marbled Gecko				x				
Gehyra variegata	Variegated Tree Dtella				x				
Pygopodidae	Legless Lizards								
Aprasia pulchella	Granite Worm-lizard				x				
Aprasia repens	Sand-plain Worm-lizard				x				
Delma fraseri					x				
Delma grayii					x				
Lialis burtonis	Burton's Legless Lizard				x				
Pletholax gracilis	Keeled Legless Lizard				x				
Pygopus lepidopodus	Common Scaly-foot				x				
Scincidae	Skinks								
Actitis hypoleucos	Western Three-lined Skink				x				
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink				x				
Cryptoblepharus plagiocephalus					x				
Ctenotus australis					x				
Ctenotus delli	Darling Range Heath Ctenotus			P4	x		x		
Ctenotus fallens					x				
Ctenotus gemmula	Jewelled South-west Ctenotus			P3	x				
Ctenotus impar	South-western Odd-stripped Ctenotus				x				
Ctenotus labillardieri					x				
Egernia kingii	King's Skink				x				
Egernia napoleonis					x				
Hemiergis initialis					x				
Hemiergis quadrilineata					x				
Lerista christinae					x				

REPTILES		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Lerista distinguenda					x				
Lerista elegans					x				
Lerista lineata	Perth Slider			P3	x		x		
Lerista lineopunctulata					x				
Lerista praepedita					x				
Menetia greyii	Common Dwarf Skink				x				
Morethia lineoocellata					x				
Morethia obscura					x				
Tiliqua occipitalis	Western Bluetongue				x				
Tiliqua rugosa subsp. *rugosa*	Bobtail				x				
Agamidae	Dragons								
Ctenophorus adelaidensis	Southern Heath Dragon				x				
Ctenophorus ornatus	Ornate Crevice Dragon				x				
Pogona minor	Bearded Dragon				x				
Varanidae	Goannas								
Varanus gouldii	Sand Monitor				x				
Varanus rosenbergi	Heath Monitor				x				
Varanus tristis	Racehorse Monitor				x				
Typhlopidae	Blind Snakes								
Ramphotyphlops australis	Southern Blind Snake				x				
Ramphotyphlops pinguis	Fat Blind Snake				x				
Ramphotyphlops waitii					x				
Boidae	Pythons								
Antaresia stimsoni	Stimpsons Python				x				
Morelia spilota subsp. *imbricata*	Carpet Python			P4	x		x		
Elapidae	Elapids								
Acanthophis antarcticus	Southern Death Adder			P3	x		x		
Brachyurophis semifasciata	Southern Shovel-nosed Snake				x				
Demansia psammophis	Yellow-faced Whipsnake				x				
Echiopsis curta	Bardick				x				
Elapognathus coronatus	western Crowned Snake				x				
Neelaps bimaculatus	Black-naped Snake				x				
Neelaps calontos	Black-striped Snake			P3	x		x		
Notechis scutatus	Tiger Snake				x				
Parasuta gouldii	Gould's Hooded Snake				x				
Parasuta nigriceps	Mitchell's Short-tailed Snake				x				
Pseudonaja affinis	Dugite				x				x
Pseudonaja modesta	Ringed Brown Snake				x				
Simoselaps bertholdi	Jan's Banded Snake				x				

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F3: AVIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CASUARIIFORMES									
Dromaiidae	Emu								
Dromaius novaehollandiae	Emu				x	x			
GALLIFORMES									
Megapodiidae	Megapodes								
Leipoa ocellata	Malleefowl	VU	S1		x		x	x	
Phasianidae	Pheasants, Fowl & Allies								
Coturnix pectoralis	Stubble Quail				x	x			
Coturnix ypsilophora	Brown Quail				x	x			
ANSERIFORMES									
Anatidae	Ducks, Geese & Swans								
Anas castanea	Chestnut Teal				x	x			
Anas gracilis	Grey Teal				x	x			
Anas platyrhynchos	Northern Mallard				x	x			
Anas rhynchotis	Australasian Shoveler				x	x			
Anas superciliosa	Pacific Black Duck				x	x			x
Aythya australis	Hardhead				x	x			
Biziura lobata	Musk Duck				x	x			
Chenonetta jubata	Maned Duck				x	x			
Cygnus atratus	Black Swan				x	x			
Malacorhynchus membranaceus	Pink-eared Duck				x	x			
Oxyura australis	Blue-billed Duck				x	x			
Stictonetta naevosa	Freckled Duck				x	x			
Tadorna tadornoides	Australian Shelduck				x	x			
PODICIPEDIFORMES									
Podicipedidae	Grebes								
Podiceps cristatus	Great Crested Grebe				x	x			
Poliocephalus poliocephalus	Hoary-headed Grebe				x	x			
Tachybaptus novaehollandiae	Australasian Grebe				x	x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
ACCIPITRIFORMES									
Accipitridae	Kites, Hawks & Eagles								
Accipiter cirrocephalus	Collared Sparrowhawk				x	x			
Accipiter fasciatus	Brown Goshawk				x	x			
Aquila audax	Wedge-tailed Eagle				x	x			
Circus approximans	Swamp Harrier				x	x			
Circus assimilis	Spotted Harrier				x	x			
Elanoides axillaris	Black-shouldered Kite				x	x			x
Haliastur sphenurus	Whistling Kite				x	x			x
Hieraaetus morphnoides	Little Eagle				x	x			
Lophoictinia isura	Square-tailed Kite				x	x			
Milvus migrans	Black Kite				x				
FALCONIFORMES									
Falconidae	Caracaras, Falcons								
Falco berigora	Brown Falcon				x	x			
Falco cenchroides	Nankeen Kestrel				x	x			x
Falco longipennis	Australian Hobby				x	x			
Falco peregrinus	Peregrine Falcon		S4		x	x	x		
OTIDIFORMES									
Otididae	Bustards								
Ardeotis australis	Australian Bustard			P4	x		x		
Rallidae	Rails, Crakes & Coots								
Fulica atra	Eurasian Coot				x	x			
Gallinula tenebrosa	Dusky Moorhen				x				
Gallirallus philippensis	Buff-banded Rail				x	x			
Porphyrio porphyrio	Purple Swamphen				x	x			
Porzana fluminea	Australian Crake				x	x			
Porzana pusilla	Baillon's Crake				x	x			
Porzana tabuensis	Spotless Crake				x	x			
Tribonyx ventralis	Black-tailed Native-hen				x	x			
CHARADRIIFORMES									
Turnicidae	Buttonquail								
Turnix varius	Painted Buttonquail				x	x			
Turnix velox	Little Buttonquail				x				
Burhinidae	Stone-curlews								
Burhinus grallarius	Bush Stone-curlew			P4	x	x	x		
COLUMBIFORMES									
Columbidae	Pigeons, Doves								
Columba livia	Rock Dove				x	x			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Ocyphaps lophotes	Crested Pigeon				X	X			X
Phaps chalcoptera	Common Bronzewing				X	X			X
Phaps elegans	Brush Bronzewing				X	X			
Spilopelia senegalensis	Laughing Dove				X	X			X
Streptopelia chinensis	Spotted Dove				X	X			
PSITTACIFORMES									
Cacatuidae	Cockatoos								
Cacatua galerita	Sulphur-crested Cockatoo				X	X			
Cacatua pastinator	Western Corella				X	X			
Cacatua sanguinea	Little Corella				X	X			
Cacatua tenuirostris	Long-billed Corella					X			
Calyptorhynchus banksii naso	Forest Red-tailed Black Cockatoo	VU	S1		X	X	X	X	
Calyptorhynchus baudinii	Baudin's Black Cockatoo	VU	S1		X	X	X	X	
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	EN	S1		X	X	X	X	
Eolophus roseicapilla	Galah				X	X			X
Lophochroa leadbeateri	Major Mitchell's Cockatoo		S4		X		X		
Nymphicus hollandicus	Cockatiel				X	X			
Psittacidae	Parrots								
Barnardius zonarius	Australian Ringneck				X	X			
Glossopsitta porphyrocephala	Purple-crowned Lorikeet				X	X			
Melopsittacus undulatus	Budgerigar				X				
Neophema elegans	Elegant Parrot				X	X			
Neophema petrophila	Rock Parrot					X			
Platycercus icterotis	Western Rosella				X	X			
Polytelis anthopeplus	Regent Parrot				X	X			
Purpureicephalus spurius	Red-capped Parrot				X	X			
Trichoglossus moluccanus	Rainbow Lorikeet				X	X			X
CUCULIFORMES									
Cuculidae	Cuckoos								
Cacomantis flabelliformis	Fan-tailed Cuckoo				X	X			
Cacomantis pallidus	Pallid Cuckoo				X	X			
Chrysococcyx basalis	Horsfield's Bronze Cuckoo				X	X			
Chrysococcyx lucidus	Shining Bronze Cuckoo				X	X			
STRIGIFORMES									
Tytonidae	Barn Owls								
Tyto delicatula	Eastern Barn Owl				X	X			
Tyto novaehollandiae	Australian Masked Owl			P3	X	X	X		
Strigidae	Owls								
Ninox boobook	Southern Boobook				X	X			
Ninox connivens	Barking Owl			P2	X	X			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CAPRIMULGIFORMES									
Podargidae	Frogmouths								
Podargus strigoides	Tawny Frogmouth				X	X			X
Caprimulgidae	Nightjars								
Eurostopodus argus	Spotted Nightjar				X	X			
APODIFORMES									
Aegothelidae	Owlet-nightjars								
Aegotheles cristatus	Australian Owlet-nightjar				X	X			
Apodidae	Swifts								
Apus pacificus	Pacific Swift	Mi	S3		X	X	X	X	
CORACIIFORMES									
Alcedinidae	Kingfishers								
Dacelo novaeguineae	Laughing Kookaburra				X	X			
Todiramphus sanctus	Sacred Kingfisher				X	X			
Meropidae	Bee-eaters								
Merops ornatus	Rainbow Bee-eater	Mi	S3		X	X	X	X	
PASSERIFORMES									
Climacteridae	Australasian Treecreepers								
Climacteris rufus	Rufous Treecreeper				X	X			
Maluridae	Australasian Wrens								
Malurus elegans	Red-winged Fairywren				X	X			
Malurus lamberti	Variegated Fairywren				X	X			
Malurus leucopterus	White-winged Fairywren				X				
Malurus splendens	Splendid Fairywren				X	X			X
Stipiturus malachurus	Southern Emu-wren				X	X			
Meliphagidae	Honeyeaters								
Acanthorhynchus superciliosus	Western Spinebill				X	X			
Anthochaera carunculata	Red Wattlebird				X	X			
Anthochaera lunulata	Western Wattlebird				X	X			
Epthianura albifrons	White-fronted Chat				X	X			
Gliciphila melanops	Tawny-crowned Honeyeater				X	X			
Lichenostomus ornatus	Yellow-plumed Honeyeater				X	X			
Lichenostomus virescens	Singing Honeyeater				X	X			
Lichmera indistincta	Brown Honeyeater				X	X			X
Manorina flavigula	Yellow-throated Miner				X	X			
Melithreptus brevirostris	Brown-headed Honeyeater				X	X			
Melithreptus lunatus	White-naped Honeyeater				X				
Phylidonyris niger	White-cheeked Honeyeater				X	X			X
Phylidonyris novaehollandiae	New Holland Honeyeater				X	X			X
Purnella albifrons	White-fronted Honeyeater					X			

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Sugomel nigrum	Black Honeyeater					X			
Pardalotidae	Pardalotes								
Pardalotus punctatus	Spotted Pardalote				X	X			
Pardalotus striatus	Striated Pardalote				X	X			
Acanthizidae	Australasian Warblers								
Acanthiza apicalis	Inland Thornbill				X	X			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				X	X			
Acanthiza inornata	Western Thornbill				X	X			
Gerygone fusca	Western Gerygone				X	X			X
Sericornis frontalis	White-browed Scrubwren				X	X			
Smicrornis brevirostris	Weebill				X	X			
Pomatostomidae	Australasian Babblers								
Pomatostomus superciliosus	White-browed Babbler				X				
Cracticidae	Butcherbirds and Allies								
Cracticus nigrogularis	Pied Butcherbird				X	X			
Cracticus torquatus	Grey Butcherbird				X	X			
Gymnorhina tibicen	Australian Magpie				X	X			
Strepera versicolor	Grey Currawong				X	X			
Artamidae	Woodswallows								
Artamus cinereus	Black-faced Woodswallow				X	X			
Artamus cyanopterus	Dusky Woodswallow				X	X			
Campephagidae	Cuckooshrikes								
Coracina novaehollandiae	Black-faced Cuckooshrike				X	X			
Lalage tricolor	White-winged Triller				X	X			X
Neosittidae	Sittellas								
Daphoenositta chrysoptera	Varied Sittella				X	X			
Pachycephalidae	Whistlers and Allies								
Colluricincla harmonica	Grey Shrikethrush				X	X			X
Pachycephala pectoralis	Australian Golden Whistler				X	X			
Pachycephala rufiventris	Rufous Whistler				X	X			X
Rhipiduridae	Fantails								
Rhipidura albiscapa	Grey Fantail				X	X			X
Rhipidura leucophrys	Willie Wagtail				X	X			X
Monarchidae	Monarchs								
Grallina cyanoleuca	Magpie-lark				X	X			X
Myiagra inquieta	Restless Flycatcher				X				
Corvidae	Crows, Jays								
Corvus bennetti	Little Crow				X	X			
Corvus coronoides	Australian Raven				X	X			X
Petroicidae	Australasian Robins								

BIRDS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
Eopsaltria georgiana	White-breasted Robin				X	X			X
Eopsaltria griseogularis	Western Yellow Robin				X	X			
Melanodryas cucullata	Hooded Robin				X	X			
Microeca fascinans	Jacky Winter				X	X			
Petroica boodang	Scarlet Robin					X			
Petroica goodenovii	Red-capped Robin				X	X			
Hirundinidae	Swallows, Martins								
Cheramoeca leucosterna	White-backed Swallow				X	X			
Hirundo neoxena	Welcome Swallow				X	X			
Petrochelidon ariel	Fairy Martin				X	X			
Petrochelidon nigricans	Tree Martin				X	X			
Acrocephalidae	Reed Warblers and Allies								
Acrocephalus australis	Australian Reed Warbler				X	X			
Locustellidae	Grassbirds and allies								
Cincloramphus cruralis	Brown Songlark				X	X			
Cincloramphus mathewsi	Rufous Songlark				X	X			
Megalurus gramineus	Little Grassbird				X	X			
Zosteropidae	White-eyes								
Zosterops lateralis	Silvereye				X	X			
Dicaeidae	Flowerpeckers								
Dicaeum hirundinaceum	Mistletoebird				X	X			
Estrildidae	Waxbills, Munias & Allies								
Lonchura castaneothorax	Chestnut-breasted Mannikin				X	X			
Stagonopleura oculata	Red-eared Firetail				X	X			
Motacillidae	Wagtails, Pipits								
Anthus australis	Australian Pipit				X	X			

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX F

F4: MAMMALIAN SPECIES RECORDED WITHIN THE VICINITY OF THE STUDY AREA

Key: EPBC = Environment Protection and Biodiversity Conservation Act 1999, WC = Wildlife Conservation Act 1950, DEC = Department of Conservation Priority Code, A = Listed in Naturemap (2012), B = Listed by Birds Australia (2012), C = Listed on the DEC Threatened and Priority Fauna Database, D = Listed by the DSEWPaC Protected Matters Search Tool, E = Current Survey

Note: For Definitions of Conservation Codes see Appendix B

MAMMALS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
MONOTREMATA									
Tachyglossidae									
Tachyglossus aculeatus	Echidna				x				
DASYUROMORPHIA									
Dasyuridae									
Antechinus flavipes	Mardo				x				
Dasyurus geoffroii	Chuditch, Western Quoll	VU	S1		x		x	x	
Phascogale tapoatafa	Wambenger, Southern Brush-tailed Phascolgale		S1		x		x		
Sminthopsis gilberti	Gilbert's Dunnart				x				
Myrmecobiidae									
Myrmecobius fasciatus	Walpurti, Numbat	VU	S1		x		x		
PERAMELEMORPHIA									
Peramelidae									
Isoodon obesulus	Quenda, Southern Brown Bandicoot			P5	x		x		x
DIPROTODONTIA									
Potoroidae									
Bettongia penicillata	Woylie, Brush-tailed Bettong	EN	S1		x			x	
Macropodidae									
Macropus eugenii	Tammar Wallaby			P5	x		x		
Macropus fuliginosus	Western Grey Kangaroo				x				
Macropus irma	Western Brush Wallaby			P4	x		x		
Setonix brachyurus	Quokka	VU	S1		x		x	x	
Phalangeridae									
Trichosurus vulpecula	Common Brushtail Possum				x				
Tarsipedidae									
Tarsipes rostratus	Honey Possum				x				
Burramyidae									
Cercartetus concinnus	Western Pygmy-possum				x				

MAMMALS		Conservation Codes							
Scientific Name	Common Name	EPBC	WC	DEC	A	B	C	D	E
CHIROPTERA									
Vespertilionidae									
Chalinolobus gouldii	Gould's Wattled Bat				x				
Chalinolobus morio	Chocolate Wattled Bat				x				
Falsistrellus mackenziei	Western False Pipistrelle			P4	x		x		
Nyctophilus geoffroyi	Lesser Long-eared Bat				x				
Nyctophilus gouldi	Gould's Long-eared Bat				x				
Vespadelus regulus	Southern Forest Bat				x				
Molossidae									
Mormopterus planiceps	Southern Freetai-bat				x				
Tadarida australis	White-striped Freetail-bat				x				
RODENTIA									
Muridae									
Hydromys chrysogaster	Water-rat			P4	x		x		
**Mus musculus*	House Mouse				x				
Rattus fuscipes	Western Bush Rat				x				
**Rattus norvegicus*	Brown Rat				x				
**Rattus rattus*	Black Rat				x				
LAGOMORPHA									
Leporidae									
**Oryctolagus cuniculus*	Rabbit				x			x	x
CARNIVORA									
Canidae									
**Vulpes vulpes*	Red Fox				x			x	
Felidae									
**Felis catus*	Cat				x			x	
ARTIODACTYLA									
Suidae									
**Sus scrofa*	Pig				x			x	
Bovidae									
**Capra hircus*	Goat							x	

[X] fauna species recorded.
[*] denotes introduced species.

APPENDIX G
FAUNA HABITAT ASSESSMENT DATA SHEETS

APPENDIX G
FAUNA HABITAT ASSESSMENT DATA SHEETS

Habitat Assessment – HA1

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	400402 E	Proportion of Project Area:	30.07%
	6443658 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale:	1 (degraded)	Last Fire:	2 (4-5 year)	Disturbance (other):	0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	2.5	2 (20-60%)
Midstorey:	-		0 (<5% cover)
Ground Cover:	Sedges (mixed), Grasses (mixed)	1	2 (20-60%)

Groundcover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Pebbles/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	1 (<20% cover)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	2 (20-60%)	Rock Crevices	0 (none)	Water Presence	1 (rare)
Grasses	0 (none)	No. of Caves	0	Distance to Water	2 (0.5-2 km)
Woody debris	2 (moderate)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 20/70

Habitat Assessment – HA2

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	400145 E	Proportion of Project Area:	30.07%
	6443751 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale: 0 (completely degraded) | Last Fire: 2 (4-5 year) | Disturbance (other): 0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	5	2 (20-60%)
Midstorey:	-		1 (<20% cover)
Ground Cover:	Pig Face and other herbs		2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	2 (0.5-2 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 18/70

Habitat Assessment – HA3

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	399754 E	Proportion of Project Area:	30.07%
	6443427 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	Limestone
Aspect:	N/A	Landform:	Inland Dune

Condition Scale: 1 (degraded) Last Fire: 2 (4-5 year) Disturbance (other): 0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	5	2 (20-60%)
Midstorey:	-		0 (<5% cover)
Ground Cover:	Pig Face, mixed herbs, grasses, sedges	0.3	1 (<20% cover)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 18/70

Habitat Assessment – HA4

Fauna Habitat:	Banksia Woodland	Total Area of Habitat:	0.16 ha
UTM Co-ordinates:	399511 E	Proportion of Project Area:	3.56%
	6444544 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	N/A
Aspect:	N/A	Landform:	Inland Dune

Condition Scale:	Last Fire:	Disturbance (other):
3 (very good)	1 (1-3 year)	0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Banksia attenuate, Banksia ilicifolila*	8	2 (20-60%)
Midstorey:			2 (20-60%)
Ground Cover:			2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	2 (<20% cover)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	0 (none)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	1 (open)

Total = 23/70

Habitat Assessment – HA5

Fauna Habitat:	Melaleuca Woodland	Total Area of Habitat:	1.34 ha
UTM Co-ordinates:	399926 E	Proportion of Project Area:	30.07%
	6444134 N	Soil Texture:	Sand
Zone:	50	Soil Colour:	Grey/White
Quadrat Size:	100 x 100	Rock Type:	N/A
Aspect:	N/A	Landform:	Inland Dune

Condition Scale: 1 (degraded) Last Fire: 1 (1-3 year) Disturbance (other): 0 (heavy)

	Species	Avg Height (m)	Score
Overstorey:	*Melaleuca* sp.	3	1 (<20% cover)
Midstorey:	*Acacia pulcher*	1.5	2 (20-60%)
Ground Cover:	Mixed herbs/grasses/pig face	0.3	2 (20-60%)

Ground Cover	Score	Microhabitats	Score	Microhabitats	Score
Bare ground	1 (20-60%)	Burrowing Suitability	3 (sand)	Peeling Bark	1 (rare)
Rock	0 (<5% cover)	Rocks/Stones (0-200 mm)	0 (none)	Large Tree Hollows (>10cm diameter)	0 (none)
Leaf Litter	2 (20-60%)	Exfoliating Slabs	0 (none)	Small Tree Hollows (<10cm diameter)	0 (none)
Logs	0 (<5% cover)	Rock Crevices	0 (none)	Water Presence	0 (none)
Grasses	1 (0-30%)	No. of Caves	0	Distance to Water	3 (<0.5 km)
Woody debris	1 (rare)	Suitability for Bats	0	Tree Connectivity	0 (none)

Total = 19/70

APPENDIX H
FLORA QUADRAT AND RELEVÉ DATA SHEETS

APPENDIX H

FLORA QUADRAT AND RELEVÉ DATA SHEETS

Keane Road Pipeline Survey Site KRZ01

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Rd

MGA Zone 50 400379 mE 6443702mN

Habitat Lower slope

Soil White/grey sand

Rock Type N/A

Vegetation Shrubland of *Melaleuca rhaphiophylla* and *Melaleuca viminea* over *Regelia ciliata* and sedges

Veg Condition Very good

Fire Age Old

Notes Adjacent to track
Bare ground: 10%

SPECIES LIST:

Name	Cover	Height	Specimen Notes
Acacia pulchella	15	1.1 m	NC
Astartea affinis	2	1.2 m	KRZ16
Briza maxima	+	0.05 m	NC
Caladenia flava			OPP
Callitris pyramidalis			KRZ17
Cassytha racemosa	2	cr	KRZ15
Caustis dioica	15	0.5 m	KRZ05
Crassula colorata var. *acuminata*	+	3 m	KRZ08
Cytogonidium leptocarpoides	3	0.25 m	KRZ13
Dampiera trigona	+	0.2 m	KRZ07
Desmocladus fasciculatus	4	0.15 m	NC
Drosera erythrorhiza			OPP
Drosera nitidula	+	1 m	KRZ14
Eutaxia virgata	2	0.7 m	KRZ04
Hakea sulcata	2	1.2 m	KRZ11
Hypochaeris glabra	2	1 m	NC
Hypolaena exsulca	15	0.4 m	NC
Lepidosperma longitudinale	30	0.45 m	NC
Melaleuca rhaphiophylla	10	2.3 m	NC
Melaleuca viminea	15	1.4 m	KRZ01
Moraea flaccida	4	0.3 m	NC
Pericalymma ellipticum			KRZ18
Poa annua	3	0.15 m	NC
Pyrorchis nigricans			KRZ19
Regelia ciliata	35	1 m	KRZ03
Stirlingia latifolia			OPP
Thysanotus sparteus	+	0.5 m	KRZ09
Tribonanthes brachypetala	1	0.3 m	KRZ06
Ursinia anthemoides			OPP
Verticordia densiflora	4	0.35 m	KRZ10

Keane Road Pipeline Survey Site KRZ02

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 400183 mE 6443880mN

Habitat Dampland

Soil Grey sand

Rock Type N/A

Vegetation Closed shrubland of *Kunzea glabrescens* over *Regelia ciliata* and sedges

Veg Condition Excellent

Fire Age Old

Notes Adjacent to track
Bare ground: 15%
Litter cover: -% logs, 10% twigs, 5% leaves
Gradient unsuitable for rainfall to run-off

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella			OPP	
Bossiaea eriocarpa			OPP	
Caladenia flava	+	0.1 m	NC	
Conostylis juncea			OPP	
Crassula colorata var. *acuminata*	+	0.03 m	KRZ08	
Cytogonidium leptocarpoides	3	0.25 m	KRZ29	
Dasypogon bromeliifolius	+	0.45 m	NC	
Desmocladus fasciculatus			OPP	
Drosera erythrorhiza	3	1 m	NC	
Gompholobium tomentosum	+	0.4 m	NC	
Hibbertia subvaginata			OPP	
Hypochaeris glabra	+	1 m	NC	
Hypolaena exsulca	6	0.3 m	NC	
Jacksonia gracillima	+	0.4 m	KRZ34	
Jacksonia sternbergiana			OPP	
Kennedia prostrata			OPP	
Kunzea glabrescens	85	4 m	KRZ27	
Lomandra sericea	+	0.4 m	KRZ31	
Neurachne alopecuroidea			OPP	
Philotheca spicata			OPP	
Phlebocarya ciliata			OPP	
Pterostylis vittata	+	0.01 m	KRZ32	
Regelia ciliata	50	1 m	KRZ03	
Sowerbaea laxiflora			OPP	
Thysanotus manglesianus	+	cr	KRZ28	
Trachymene pilosa	+	0.02 m	NC	
Xanthorrhoea preissii	1.5	1.1 m	NC	

Keane Road Pipeline Survey Site KRZ03

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399833 mE 6444227mN

Habitat Dampland

Soil Grey sand

Rock Type N/A

Vegetation Open woodland of *Melaleuca preissiana* over *Regelia ciliata*

Veg Condition Excellent

Fire Age Old

Notes Bare ground: 10%
Litter cover: -% logs, 3% twigs, 2% leaves

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	6	1.3 m	NC	
Banksia attenuata			OPP	
Caladenia flava			OPP	
Dampiera alata			OPP	
Dasypogon bromeliifolius	3	0.4 m	NC	
Euchilopsis linearis	3	0.3 m	KRZ37	
Hypocalymma angustifolium	7	0.55 m	NC	
Hypochaeris glabra	4	0.01 m	NC	
Hypolaena exsulca	5	0.35 m	NC	
Jacksonia gracillima	+	0.35 m	KRZ34	
Kunzea glabrescens	4	2 m	KRZ27	
Lepidosperma longitudinale	+	0.55 m	KRZ36	
Melaleuca preissiana	10	4 m	NC	
Philotheca spicata	+	1 m	NC	
Phlebocarya ciliata			OPP	
Pimelea angustifolia	1.5	1.1 m	KRZ38	
Pterostylis vittata	+	0.15 m	KRZ30	
Regelia ciliata	80	1.5 m	KRZ03	
Ursinia anthemoides	+	0.25 m	NC	
Xanthorrhoea preissii	3	1.2 m	NC	

Keane Road Pipeline Survey Site KRZ04

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399506 mE 6444542mN

Habitat Lower slope

Soil Grey sand

Rock Type N/A

Vegetation *Banksia attenuata* and *B. illicifolia* woodland over *Kunzea glabrescens* and *Dasypogon bromeliifolius*

Veg Condition Excellent

Fire Age Young

Notes Bare ground: 10%
Litter cover: 2% logs, 8% twigs, 5% leaves

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	5	1.5 m	NC	
Adenanthos cygnorum	1	1.5 m	NC	
Aotus procumbens	+	0.6 m	KRZ41	
Banksia attenuata	25	12 m	NC	
Banksia ilicifolia	5	10 m	NC	
Briza maxima			OPP	
Carpobrotus edulis			OPP	
Conostylis juncea	+	0.15 m	NC	
Dampiera alata			OPP	
Dasypogon bromeliifolius	15	0.3 m	NC	
Gompholobium tomentosum	2	0.5 m	NC	
Hemiandra pungens			OPP	
Hibbertia subvaginata	20	0.4 m	NC	
Hypochaeris glabra	+	0.4 m	NC	
Hypolaena exsulca	+	0.3 m	KRZ40	
Kunzea glabrescens	40	2.5 m	KRZ27	
Lechenaultia biloba			OPP	
Lomandra nigricans	+	0.2 m	NC	
Lyginia imberbis	3	0.3 m	NC	
Melaleuca thymoides	2	1.4 m	KRZ39	
Nuytsia floribunda			OPP	
Patersonia occidentalis	+	0.4 m	NC	
Petrophile linearis	+	0.5 m	NC	
Philotheca spicata	+	0.4 m	NC	
Phlebocarya ciliata	2	0.3 m	NC	
Pimelea angustifolia	+	0.2 m	KRZ38	
Scholtzia involucrata	1.5	0.4 m	NC	
Trachymene pilosa	+	0.1 m	NC	
Ursinia anthemoides	+	0.2 m	NC	
Xanthorrhoea preissii	1	1 m	NC	

Keane Road Pipeline Survey Site KRZ05

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 10 x 10 m

Location Keane Road

MGA Zone 50 399600 mE 6443568mN

Habitat Dampland

Soil Dark grey surface clay with sand at depth

Rock Type N/A

Vegetation Low shrubland of *Melaleuca viminea* over herbs

Veg Condition Excellent

Fire Age

Notes Quadrat was positioned outside of survey area but the vegetation inside is still of the same community type however it is in good condition and sandwiched between two tracks

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Cassytha racemosa	6	+	KRZ15	
Centrolepis polygyna	4	0.02 m	KRZ44	
Crassula natans var. *minus*	3	0.03 m	KRZ45	
Hypochaeris glabra	+	0.01 m	NC	
Isolepis cernua var. *setiformis*	+	0.03 m	KRZ48	
Lotus subbiflorus	2	0.03 m	KRZ46	
Melaleuca viminea	30	1.2 m	KRZ43	
Moraea flaccida	+	0.4 m	NC	
Vulpia myuros	+	0.05 m	KRZ47	

Keane Road Pipeline Survey Site KRZ06

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Quadrat 4 x 25 m

Location Keane Road

MGA Zone 50 399820 mE 6443421mN

Habitat Dampland

Soil Dark grey sand - bleached on surface

Rock Type N/A

Vegetation *Melaleuca preissiana* over *Kunzea glabrescens* over *Regelia ciliata* and *Melaleuca viminea* over *Moraea flaccida* and *Baumea juncea*

Veg Condition Excellent

Fire Age Moderate

Notes Bare ground: 5%
Litter cover: 1% logs, 4% twigs, 1% leaves
Disturbances: weeds

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia pulchella	2	0.4 m	NC	
Arctotheca calendula	+	0.1 m	NC	
Baumea juncea	6	0.6 m	KRZ49	
Briza maxima	+	0.1 m	NC	
Cassytha racemosa	3	cr	KRZ15	
Cortaderia selloana	2	1.5 m	NC	
Cynodon dactylon	15	0.1 m	NC	
Dasypogon bromeliifolius			OPP	
Ehrharta longiflora	2	1 m	NC	
Hakea varia	1	0.5 m	NC	
Hypolaena exsulca	1.5	0.5 m	NC	
Jacksonia sternbergiana	+	1.5 m	NC	
Juncus pallidus	3	1.1 m	NC	
Kennedia prostrata	+	0.1 m	NC	
Kunzea glabrescens	8	2.1 m	KRZ27	
Lepidosperma longitudinale	4	1 m	NC	
Lotus subbiflorus	3	0.05 m	KRZ46	
Melaleuca preissiana	6	7 m	NC	
Melaleuca viminea	20	1.2 m	KRZ43	
Moraea flaccida	10	0.35 m	NC	
Patersonia occidentalis	+	0.4 m	NC	
Phlebocarya ciliata			OPP	
Regelia ciliata	5	1.3 m	KRZ03	
Sowerbaea laxiflora			OPP	

Keane Road Pipeline Survey Site KRZ A

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400416 mE 6443659mN
Soil White sand
Vegetation Melaleuca viminea over weed infested understorey

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Briza maxima	1		NC	
Drosera glanduligera	+		KRZ02	
Ehrharta longiflora	2		NC	
Eragrostis curvula	3		NC	
Hypolaena exsulca	+		NC	
Lepidosperma longitudinale	15		NC	
Melaleuca viminea	50		KRZ01	
Moraea flaccida	+		NC	
Poa annua	3		NC	

Keane Road Pipeline Survey Site KRZ B

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400374 mE 6443687mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Gahnia trifida	20		NC	
Melaleuca rhaphiophylla	60		NC	

Keane Road Pipeline Survey Site KRZ C

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399528 mE 6443643mN
Notes Tracks are flooded. Rubbish dumped all around site.

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Arctotheca calendula	2		NC	
Cynodon dactylon	5		NC	
Lepidosperma longitudinale	30		NC	
Melaleuca viminea	40		KRZ01	
Moraea flaccida	+		NC	
Zantedeschia aethiopica	+		NC	

Keane Road Pipeline Survey Site KRZ D

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399666 mE 6443507 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Acacia saligna	5		NC	
Arctotheca calendula	2		NC	
Carpobrotus edulis	5		NC	
Hakea varia	3		NC	
Jacksonia sternbergiana	2		NC	
Kunzea glabrescens	20		NC	
Melaleuca rhaphiophylla	40		NC	
Pimelea angustifolia	+		KRZ38	
Regelia ciliata	20		KRZ03	

Keane Road Pipeline Survey Site KRZ OPP 1

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400311 mE 6443748 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Banksia sphaerocarpa var. *sphaerocarpa*	3		KRZ21	PH 698
Drosera marchantii subsp. *marchantii*	+		KRZ23	
Drosera menziesii subsp. *menziesii*	+		KRZ24	
Kunzea micrantha	30		KRZ22	PH 697
Petrophile rigida	4		KRZ20	PH 696

Keane Road Pipeline Survey Site KRZ OPP 10

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399477 mE 6444576 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	+		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 11

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399461 mE 6444592 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	+		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 12

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399182 mE 6443988 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	4 ind		NC	

Keane Road Pipeline Survey Site KRZ OPP 13

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399196 mE 6443975 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Moraea flaccida	+		NC	

Keane Road Pipeline Survey Site KRZ OPP 14

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399208 mE 6443962 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	4 ind		NC	

Keane Road Pipeline Survey Site KRZ OPP 15

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399566 mE 6443609mN
Notes Located in the middle of a flooded track

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Eleocharis acuta	15		KRZ42	Ph 729-730

Keane Road Pipeline Survey Site KRZ OPP 16

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399700 mE 6443482mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Moraea flaccida	100+ ind		NC	
Zantedeschia aethiopica	1 ind		NC	

Keane Road Pipeline Survey Site KRZ OPP 17

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400113 mE 6443732mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Zantedeschia aethiopica	5 ind		NC	

Keane Road Pipeline Survey Site KRZ OPP 18

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400181 mE 6443793mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	3 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 19

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400113 mE 6443732 mN
Soil Grey sand

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Corymbia calophylla	1 ind	8 m	KRZ50	

Keane Road Pipeline Survey Site KRZ OPP 2

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400311 mE 6443766 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Drosera glanduligera	+		KRZ02	
Drosera menziesii subsp. *menziesii*	+		KRZ25	

Keane Road Pipeline Survey Site KRZ OPP 3

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400278 mE 6443792 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Stylidium repens	2 ind		KRZ26	

Keane Road Pipeline Survey Site KRZ OPP 4

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400260 mE 6443801 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Melaleuca cuticularis	3 ind		KRZ27	

Keane Road Pipeline Survey Site KRZ OPP 5

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400081 mE 6443977 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 6

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 400014 mE 6444041 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

Keane Road Pipeline Survey Site KRZ OPP 7

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399928 mE 6444127 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia furcellata	5 ind		KRZ35	

Keane Road Pipeline Survey Site KRZ OPP 8

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399900 mE 6444163 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia furcellata	1 ind		KRZ35	

Keane Road Pipeline Survey Site KRZ OPP 9

Described by N. WHITTINGTON AND D. BULLER Date 18/09/2012 Type Opportunistic
Location Keane Road
MGA Zone 50 399678 mE 6444376 mN

SPECIES LIST:

Name	Cover	Height	Specimen	Notes
Jacksonia gracillima	2 ind		KRZ34	

APPENDIX I
FLORA BY SITE MATRIX

Appendix I FLORA BY SITE MATRIX

Species	KRZ A	KRZ B	KRZ C	KRZ D	KRZ01	KRZ02	KRZ03	KRZ04	KRZ05	KRZ06	KRZ OPP 1	KRZ OPP 10	KRZ OPP 11	KRZ OPP 12	KRZ OPP 13	KRZ OPP 14	KRZ OPP 15	KRZ OPP 16	KRZ OPP 17	KRZ OPP 18	KRZ OPP 19	KRZ OPP 2	KRZ OPP 3	KRZ OPP 4	KRZ OPP 5	KRZ OPP 6	KRZ OPP 7	KRZ OPP 8	KRZ OPP 9
Acacia pulchella					15		6	5		2																			
Acacia saligna				5																									
Adenanthos cygnorum								1																					
Aotus procumbens								+																					
Arctotheca calendula			2	2						+																			
Astartea affinis					2																								
Banksia attenuata								25																					
Banksia ilicifolia								5																					
Banksia sphaerocarpa var. *sphaerocarpa*											3																		
Baumea juncea										6																			
Bossiaea eriocarpa																													
Briza maxima	1				+					+																			
Caladenia flava						+																							
Callitris pyramidalis																													
Carpobrotus edulis				5																									
Cassytha racemosa					2				6	3																			
Caustis dioica					15																								
Centrolepis polygyna									4																				
Conostylis juncea								+																					
Cortaderia selloana										2																			
Corymbia calophylla																					1 ind								
Crassula colorata var. *acuminata*					+	+																							
Crassula natans var. *minus*									3																				
Cynodon dactylon			5							15																			
Cytogonidium leptocarpoides						3	3																						
Dampiera alata																													
Dampiera trigona					+																								
Dasypogon bromeliifolius						+	3	15																					
Desmocladus fasciculatus					4																								
Drosera erythrorhiza						3																							
Drosera glanduligera	+																					+							
Drosera marchantii subsp. *marchantii*											+																		
Drosera menziesii subsp. *menziesii*											+											+							
Drosera nitidula					+																								
Ehrharta longiflora	2									2																			
Eleocharis acuta																	15												
Eragrostis curvula	3																												
Euchilopsis linearis							3																						
Eutaxia virgata					2																								
Gahnia trifida		20																											
Gompholobium tomentosum						+		2																					
Hakea sulcata					2																								
Hakea varia				3						1																			
Hemiandra pungens																													
Hibbertia subvaginata								20																					
Hypocalymma angustifolium							7																						
Hypochaeris glabra					2	+	4	+	+																				
Hypolaena exsulca	+				15	6	5	+		1.5																			
Isolepis cernua var. *setiformis*									+																				
Jacksonia furcellata																											5 ind	1 ind	
Jacksonia gracillima						+	+					+	+							3 ind					2 ind	2 ind			2 ind
Jacksonia sternbergiana				2						+																			
Juncus pallidus										3																			
Kennedia prostrata										+																			
Kunzea glabrescens				20		85	4	40		8																			
Kunzea micrantha											30																		
Lechenaultia biloba																													
Lepidosperma longitudinale	15		30		30		+			4																			
Lomandra nigricans								+																					
Lomandra sericea						+																							
Lotus subbiflorus									2	3																			
Lyginia imberbis								3																					
Melaleuca cuticularis																								3 ind					
Melaleuca preissiana							10			6																			
Melaleuca rhaphiophylla		60		40	10																								
Melaleuca thymoides								2																					
Melaleuca viminea	50		40		15				30	20																			
Moraea flaccida	+		+		4				+	10					+			100+ ind											
Neurachne alopecuroidea																													
Nuytsia floribunda																													
Patersonia occidentalis								+		+																			
Pericalymma ellipticum																													
Petrophile linearis								+																					
Petrophile rigida											4																		
Philotheca spicata							+	+																					
Phlebocarya ciliata								2																					
Pimelea angustifolia				+			1.5	+																					
Poa annua	3				3																								
Pterostylis vittata						+	+																						
Pyrorchis nigricans																													
Regelia ciliata				20	35	50	80			5																			
Scholtzia involucrata								1.5																					
Sowerbaea laxiflora																													
Stirlingia latifolia																													
Stylidium repens																							2 ind						
Thysanotus manglesianus						+																							
Thysanotus sparteus					+																								
Trachymene pilosa						+		+																					
Tribonanthes brachypetala					1																								
Ursinia anthemoides							+	+																					
Verticordia densiflora					4																								
Vulpia myuros									+																				
Xanthorrhoea preissii						1.5	3	1																					
Zantedeschia aethiopica			+											4 ind		4 ind		1 ind	5 ind										

APPENDIX J
FLORA INVENTORY

APPENDIX J

FLORA INVENTORY

Family	Species
Aizoaceae	**Carpobrotus edulis*
Anarthriaceae	*Lyginia imberbis*
Araceae	**Zantedeschia aethiopica*
Araliaceae	*Trachymene pilosa*
Asparagaceae	*Lomandra nigricans*
	Lomandra sericea
	Sowerbaea laxiflora
	Thysanotus manglesianus
	Thysanotus sparteus
Asteraceae	**Arctotheca calendula*
	**Hypochaeris glabra*
	**Ursinia anthemoides*
Centrolepidaceae	*Centrolepis polygyna*
Crassulaceae	*Crassula colorata* var. *acuminata*
	**Crassula natans* var. *minus*
Cupressaceae	*Callitris pyramidalis*
Cyperaceae	*Baumea juncea*
	Caustis dioica
	Eleocharis acuta
	Gahnia trifida
	Isolepis cernua var. *setiformis*
	Lepidosperma longitudinale
Dasypogonaceae	*Dasypogon bromeliifolius*
Dilleniaceae	*Hibbertia subvaginata*
Droseraceae	*Drosera erythrorhiza*
	Drosera glanduligera
	Drosera marchantii subsp. *marchantii*
	Drosera menziesii subsp. *menziesii*
	Drosera nitidula
Fabaceae	*Acacia pulchella*
	Acacia saligna
	Aotus procumbens
	Bossiaea eriocarpa
	Euchilopsis linearis
	Eutaxia virgata
	Gompholobium tomentosum
	Jacksonia furcellata
	Jacksonia gracillima

Family	Species
	Jacksonia sternbergiana
	Kennedia prostrata
	**Lotus subbiflorus*
Goodeniaceae	*Dampiera alata*
	Dampiera trigona
	Lechenaultia biloba
Haemodoraceae	*Conostylis juncea*
	Phlebocarya ciliata
	Tribonanthes brachypetala
Iridaceae	**Moraea flaccida*
	Patersonia occidentalis
Juncaceae	*Juncus pallidus*
Lamiaceae	*Hemiandra pungens*
Lauraceae	*Cassytha racemosa*
Loranthaceae	*Nuytsia floribunda*
Myrtaceae	*Astartea affinis*
	Corymbia calophylla
	Hypocalymma angustifolium
	Kunzea glabrescens
	Kunzea micrantha
	Melaleuca cuticularis
	Melaleuca preissiana
	Melaleuca rhaphiophylla
	Melaleuca thymoides
	Melaleuca viminea
	Pericalymma ellipticum
	Regelia ciliata
	Scholtzia involucrata
	Verticordia densiflora
Orchidaceae	*Caladenia flava*
	Pterostylis vittata
	Pyrorchis nigricans
Poaceae	**Briza maxima*
	**Cortaderia selloana*
	**Cynodon dactylon*
	**Ehrharta longiflora*
	**Eragrostis curvula*
	Neurachne alopecuroidea
	**Poa annua*
	**Vulpia myuros*
Proteaceae	*Adenanthos cygnorum*
	Banksia attenuata

Family	Species
	Banksia ilicifolia
	Banksia sphaerocarpa var. *sphaerocarpa*
	Hakea sulcata
	Hakea varia
	Petrophile linearis
	Petrophile rigida
	Stirlingia latifolia
Restionaceae	*Cytogonidium leptocarpoides*
	Desmocladus fasciculatus
	Hypolaena exsulca
Rutaceae	*Philotheca spicata*
Stylidiaceae	*Stylidium repens*
Thymelaeaceae	*Pimelea angustifolia*
Xanthorrhoeaceae	*Xanthorrhoea preissii*

APPENDIX K
LOCATIONS OF PRIORITY FLORA

APPENDIX K

LOCATIONS OF PRIORITY FLORA

Taxa	Conservation Code	Site Number	Number of individuals/ cover	# Easting	# Northing
Jacksonia gracillima	P3	KRZ02	1	400183	6443880
		KRZ03	1	399833	6444227
		OPP	1	399477	6444576
		OPP	1	399461	6444592
		OPP	3	400181	6443793
		OPP	2	400081	6443977
		OPP	2	400014	6444041
		OPP	2	399678	6444376

Australian Geocentric 1994 (GDA94), Zone 50K

APPENDIX L
LOCATIONS OF INTRODUCED FLORA

APPENDIX L

LOCATIONS OF INTRODUCED FLORA

Taxa	Site Number	Number of Individuals/Cover %	Easting	Northing
**Arctotheca calendula*	KRZ06	<1%	399820	6443421
	Opp Coll	2%	399528	6443643
	Opp Coll	2%	399666	6443507
**Briza maxima*	KRZ01	<1%	400379	6443702
	KRZ04	<1%	399506	6444542
	KRZ06	<1%	399820	6443421
	Opp Coll	1%	400416	6443659
**Carpobrotus edulis*	KRZ04	<1%	399506	6444542
	Opp Coll	5%	399666	6443507
**Cortaderia selloana*	KRZ06	2%	399820	6443421
**Crassula natans* var. *minus*	KRZ05	3%	399600	6443568
**Cynodon dactylon*	KRZ06	15%	399820	6443421
	Opp Coll	5%	399528	6443643
**Ehrharta longiflora*	KRZ06	2%	399820	6443421
	Opp Coll	2%	400416	6443659
**Eragrostis curvula*	Opp Coll	3%	400416	6443659
**Hypochaeris glabra*	KRZ01	2%	400379	6443702
	KRZ02	<1%	400183	6443880
	KRZ03	4%	399833	6444227
	KRZ04	<1%	399506	6444542
	KRZ05	<1%	399600	6443568
**Lotus subbiflorus*	KRZ05	2%	399600	6443568
	KRZ06	3%	399820	6443421
**Moraea flaccida*	KRZ01	4%	400379	6443702
	KRZ05	<1%	399600	6443568
	KRZ06	10%	399820	6443421
	Opp Coll	<1%	400416	6443659
	Opp Coll	<1%	399528	6443643
	Opp Coll	<1%	399196	6443975
	Opp Coll	100 individuals	399700	6443482
**Poa annua*	KRZ01	3%	400379	6443702
	Opp Coll	3%	400416	6443659
**Ursinia anthemoides*	KRZ01	<1%	400379	6443702
	KRZ03	<1%	399833	6444227

Taxa	Site Number	Number of Individuals/Cover %	Easting	Northing
	KRZ04	<1%	399506	6444542
**Vulpia myuros*	KRZ05	<1%	399600	6443568
**Zantedeschia aethiopica*	Opp Coll	<1%	399528	6443643
	Opp Coll	4 individuals	399182	6443988
	Opp Coll	4 individuals	399208	6443962
	Opp Coll	1 individual	399700	6443482
	Opp Coll	5 individuals	400113	6443732

Australian Geocentric 1994 (GDA94), Zone 50K

APPENDIX M
POTENTIALLY OCCURRING CONSERVATION SIGNIFICANT FAUNA

APPENDIX M

POTENTIALLY OCCURRING CONSERVATION SIGNIFICANT FAUNA

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
REPTILES				
Darling Range Heath Ctenotus (*Ctenotus delli*)	P4	This species occurs in the Darling Range from Mundaring and Darlington south to Collie (Bush et al., 2007). It is patchily distributed in its geographic range and inhabits jarrah and marri woodlands over a shrubby understorey on lateritic, sandy and clay soils and occasionally granite and lateritic outcrops (Wilson & Swan, 2010).	There are two records of the Darling Range Heath Ctenotus within the vicinity of the study area, one from Thornlie in November 1986 and one from Byford in August 1969 (DEC, 2012e). These records are relatively old and the skinks distribution is likely to have contracted in this time. In addition the preferred habitat of the species (eucalypt woodland over heavy soils) does not occur in the study area.	Unlikely
Jewelled South-west Ctenotus (swan coastal plain population) (*Ctenotus gemmula*)	P3	The Swan Coastal Plain population of Jewelled Ctenotus occurs in pale sandplains supporting heaths in association with banksia or mallee woodlands. This species has a patchy distribution along the coastal plains and adjacent interior of the southwest (Wilson & Swan, 2010).	There are eight records located within the vicinity of the study area; the records range from 1971 to 1979 (DEC, 2012e). There are no records of the skink from the metro area within the past 20 years (DEC, 2012e), as such it is likely the Swan Coastal Plain population is extremely rare and perhaps locally extinct. The banksia woodlands within the study area are too heavily disturbed to support this species.	Unlikely
Perth Slider (*Lerista lineata*)	P3	The Perth Slider occurs in sandy coastal heath and shrubland areas in isolated populations in the south-west and midwest coast of Western Australia (Wilson & Swan, 2010). This burrowing species is found in loose soil or sand beneath logs and termite mounds, where it feeds on termites and other small insects (Cogger, 2000).	There are 256 records of the Perth Slider within the vicinity of the study area. Records are dated from 1972 to 2010 with the most recent record coming from Bibra Lake (DEC, 2012e). The sandy soils within the banksia woodland are suited to this species but are however heavily disturbed and border cleared tracks which may deter the species.	Possible

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Southwest Carpet Python (*Morelia spilota imbricata)*	P4	The southwest Carpet Python has a wide distribution but is generally uncommon. It inhabits semi-arid coastal and inland habitats such as banksia and eucalypt woodlands, and grasslands (Wilson & Swan, 2010). The species shelters in tree hollows, disused burrows, caves, rock crevices and beneath boulders (Pearson, 1993). This sub-species is thought to be declining markedly as urban areas expand causing loss of its habitat (Wilson & Swan, 2010).	There are seven records of the Southwest Carpet Python within the vicinity of the study area (DEC, 2012e). The records are dated from 1966 to 2003 and. There are few recent records of the species within the Perth region and it appears that all records are all situated to the east of the study area on the Darling Scarp (DEC, 2012e).	Unlikely
Southern Death Adder (*Acanthophis antarcticus*)	P3	The Southern Death Adder is distributed in the Darling Range between Mundaring to Jarrahdale but also distributed within the vicinity of Esperance across the Nullarbor and up most of eastern Australia (Cogger, 2000). Habitats are highly variable ranging from rainforest to shrublands and heaths. Adults feed largely on small mammals and birds and juveniles feed on reptiles (Cogger, 2000). Declines are mainly due to habitat destruction and altered fire regimes (Wilson & Swan 2010).	There are thirty-five records of the Southern Death Adder within the vicinity of the study area (DEC, 2012e). The records are dated from 1953 to 1982 and are all situated to the east of the study area on the Darling Scarp (DEC, 2012e). There are no recent records of the species within the Perth region. In the metro area, the Southern Death Adder prefers forests like those situated to the east of the study area which contain high amounts of woody debris and leaf litter and are not found in the study area.	Unlikely
Black-striped Snake (*Neelaps calontos*)	P3	The Black-striped Snake is exclusively distributed on the Swan Coastal Plain from Lancelin to Mandurah. It occupies sandplain habitat and is often associated with *Banksia* (Storr et al., 2002). The species was formerly listed as threatened fauna but has since been removed due to its abundance in banksia woodlands of the Swan Coastal Plain (Storr et al., 2002). The primary threat of the species is the ongoing clearing of habitat (Storr et al., 2002).	There are sixteen records of the Black-striped Snake within the vicinity of the study area. The banksia woodland of the study area contains soft sand, well-represented understorey vegetation and high leaf litter content suited for the species (Wilson & Swan, 2010). The species has however, not been recorded in the vicinity of the study area since 1979 (DEC, 2012e).	Possible
BIRDS				

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Malleefowl (*Leipoa ocellata*)	Vu; S1	Malleefowl occur in scattered locations across much of southern Australia (Barrett et al., 2003). In southwest WA the Malleefowl inhabits remnant vegetation of agricultural zones (Johnstone & Storr, 1998). The Malleefowl requires sandy substrate and abundant leaf litter to create large mounds which are used for breeding (Johnstone & Storr, 1998). Declines of the Mallefowl are strongly linked to alteration of habitat by the clearing and fragmentation of habitat, predation by foxes and cats and inappropriate fire regimes. (Parsons et al., 2008).	There is one record of the Malleefowl which is situated approximately 12 km to the south-east of the study area (DEC, 2012e). The record was taken in 2004 from Mundlinup State Forest in Jarrahdale on the Darling Scarp (DEC, 2012e). The record represents the western extend of the species distribution for the approximate latitude. The study area contains no suitable habitat and sits outside the species distribution (Garnett et al., 2011).	Highly Unlikely
Peregrine Falcon (*Falco peregrinus*)	S4	The Peregrine Falcon is an uncommon but wide-ranging Australian species. They mainly occur along coastal cliffs, rivers and ranges as well as wooded watercourses and lakes (Johnstone & Storr, 1998; Olsen et al., 2004). The Peregrine Falcon nests primarily on cliffs, granite outcrops, quarries and old Raven and Whistling Kite nests and feeds primarily on birds (Johnstone & Storr, 1998).	There are 82 records of the Peregrine Falcon within the vicinity of the study area (DEC, 2012e). Records are dated from 1998 to 2009, a third coming from the nearby Forrestdale Lake situated 1 km to the south of the study area. The study area provides no nesting habitat for the species. The Peregrine Falcon has a home-range of approximately 20-30 km^2 (Birdlife Australia, 2012b). Consequently it is possible that the species will pass over the study area as part of its greater home-range.	Possible
Australian Bustard (*Ardeotis australis*)	P4	The Australian Bustard is typically widespread and nomadic, but locally scarce. This species is distributed across most of Western Australia, although it's most prevalent in grasslands, especially tussock grasses, arid scrub and dry open woodlands (Ziembicki, 2010). The abundance of this species varies according to habitat and season, and birds often track resources that are in abundance, such as grasshoppers (Ziembicki, 2010).	There are two records of the Australian Bustard from within the vicinity of the study area (DEC, 2012e). The records come from Harry Waring Marsupial Reserve (1979) and Lockyer Park (DEC, 2012e). The study area does not provide suitable habitat for the Australian Bustard. The study area is situated at the southern extend of the species range and is rarely recorded within this region (Johnstone & Storr, 1998).	Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Bush Stone-curlew (*Burhinus grallarius*)	P4	The Bush Stone-curlew inhabits dry open woodlands with a groundcover of small sparse shrubs and grass avoiding dense forest and closed-canopy habitats (Johnstone & Storr, 1998). The species generally occurs near watercourses and swamps (Geering et al., 2007). Bush Stone-curlews are locally rare because of predation by foxes, which is the main concern for their regional decline (Johnstone & Storr, 1998).	There are three records of the Bush Stone-Curlew from the vicinity of the study area. The records are extremely old, dated at 1917, 1936 and 1962. While the study area provides suitable habitat for the species, there are almost no recent records of the species from within the metropolitan area implying that species is significantly rare within the region or locally extinct.	Unlikely
Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)	Vu; S1	The Forest Red-tailed Black Cockatoo is endemic to the southwest of WA, distributed from Gingin through the Darling Ranges to Albany (Johnstone & Storr, 1998). The species lives in forests of the southwest, feeding primarily on seeds of Marri nuts and nesting in large tree hollows, of Marri, Jarrah and Karri. Nest hollow shortage is considered the principal threat to the species with over 36% of the species former habitat cleared for agriculture (Garnett et al., 2011; Johnstone & Kirkby, 1999). Expected population declines >30% have been postulated over the next three generations (Chapman, 2007).	There are 58 records of the Forest Red-tailed Black Cockatoo from within the vicinity of the study area. Records are dated from 1891 to 2010 (DEC, 2012e). The species has a wide-distribution within the southwest and occupies a large home range extending on the Swan Coastal Plain mainly for foraging. The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provides ideal foraging habitat for the species.	Likely
Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)	Vu; S1	Baudin's Cockatoo is distributed from the northern Darling Range, south to Bunbury and across to Albany (Johnstone & Storr, 1998). This species forages primarily in Eucalypt forest, feeding on Marri nuts, flowers, nectar and buds as well as a wide range of seeds of *Eucalyptus*, *Banksia* and *Hakea*, (Johnstone & Kirkby, 2008; Johnstone & Storr, 1998). Baudin's Cockatoo nests in tree hollows in the deep south-west of Western Australia. Primary nesting trees are Karri, Marri, and Wandoo (Johnstone & Kirkby, 2008). Nest hollow shortage is considered the principal threat, as such the species no longer occupies over 25% of former habitat due to clearing (Chapman, 2007)	There are 163 records of Baudin's Cockatoo from within the vicinity of the study area. The records are dated from 1977 to 2009 (DEC, 2012e). The species has a wide-distribution within the southwest occupying a large home range and considered to be relatively nomadic in its movements (Johnstone & Kirkby, 2011). The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provide ideal foraging habitat for the species.	Likely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)	En; S1	Carnaby's Cockatoo is endemic to southwest WA, distributed from the Murchison River to Esperance (Cale, 2003). Breeding occurs in the Wheatbelt from early July to mid-December (Johnstone & Storr, 1998). They feed on seeds, nuts and flowers of a variety of native and exotic plants particularly Eucalypts such as Marri (*Corymbia calophylla*) and Jarrah (*Eucalyptus marginata*), *Banksia* and other Proteaceous species (Shah, 2006). Trees used as nest sites by Carnaby's Cockatoo are mature, hollow-bearing trees, usually with a crown containing dead limbs and a sparse canopy (Cale, 2003; Johnstone & Storr, 1998). Primary threats to the species are reductions of foraging and breeding habitat.	There are 432 records of Carnaby's Cockatoo from within the vicinity of the study area (DEC, 2012e). The records are dated from 1967 to 2012 (DEC, 2012e). The species has a wide-distribution within the southwest occupying a large home range and considered to be nomadic in its movements outside of breeding season (Johnstone & Kirkby, 2011). The study area provides no potential breeding or roosting habitat although the banksia woodlands within the study area provide ideal foraging habitat for the species.	Likely
Major Mitchell's Cockatoo (*Lophochroa leadbeateri*)	S4	Major Mitchell's Cockatoo has a widespread but disjunct distribution in arid and semi-arid zones of WA (Johnstone & Storr, 1998). They prefer open woodlands with access to water and require eucalypts with hollows for nesting, particularly River-gum and Salmon Gum (Rowley & Chapman, 1991). Major Mitchell feeds primarily on seed, fruit and flowers of a wide range of species including those from the *Grevillea* and *Acacia* genera (Rowley & Chapman, 1991).	There is one record of the species from within the vicinity of the study area (DEC, 2012e). The record is a specimen from the Western Australian Museum and taken from South Perth (DEC, 2012e). There are four records of this species in the metropolitan area. However the species distribution no longer extends this far west from the wheatbelt. Furthermore the study area provides no habitat for the species.	Highly Unlikely
Australian Masked Owl (*Tyto novaehollandiae novaehollandiae*)	P3	The Masked Owl is represented by two disjunct populations. In the south-west of WA, the species is distributed from Yanchep to Albany (Johnstone & Storr, 1998). It breeds in the forested deep south-west, with some autumn-winter movement northwards and north-westwards (Johnstone & Storr, 1998). The major threat to this species is the decline in nesting site availability because of clearing and the decline in the number of small mammals due to fox and cat predation (Johnstone & Storr, 1998).	There are four records of the Masked Owl within the vicinity of the study area (DEC, 2012e). The records are dated from 1919 to 2005 and occur in Burswood, Henderson and Beeliar (DEC, 2012e). The Masked Owl requires wooded forest tall trees that contain hollows for nesting (Johnstone & Storr, 1998); this habitat is not found within the study area. Habitats represented within the study area are highly disturbed and are not suitable to support this species.	Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Barking Owl (*Ninox connivens connivens*)	P2	This subspecies is distributed through southwest WA, north to Perth, east to Northam and south to Bremer Bay (Johnstone & Storr, 1998). This subspecies is disjunct from populations in the Pilbara and Kimberley. It inhabits dense vegetation particularly forests and thickets where it feeds on large insects and small mammals (Johnstone & Storr, 1998). This species breeds in hollow tree trunks and threatened primarily by clearing (Garnett & Crowley, 2000)	There are five records of the Barking Owl from within the vicinity of the study area. The records are dated from 2000 to 2010 and taken from the Beeliar Wetlands and Walliston on the Darling Scarp. The study area provides no suitable habitat for the species. The area contains a high proportion of disturbed habitat and contains no tall and hollow bearing trees which are needed for hunting and nesting.	Unlikely
Pacific Swift (*Apus pacificus*)	Mi; S3	The Pacific Swift is a non-breeding summer migrant (October-April) to Australia (Johnstone & Storr, 1998). The Pacific Swift is almost exclusively an aerial species, which forages high above the tree canopy (from 1-300 m above ground) for insects such as bees, wasps and moths (Higgins, 1999). They are believed to roost aerially but are occasionally observed to land (Higgins, 1999). They can occur over most habitat in Australia particularly inland plains, cliffs, beaches and islands (Higgins, 1999).	The Pacific Swift forages high in the airspace, is a highly mobile species and occurs across a range of habitat within Australia. The study area may provide some habitat for this species although the nearest two records are located 35-40 km east of the study area (DEC, 2012b). The species may overfly the study area occasionally but is not dependent on the habitat presented.	Possible
Rainbow Bee-eater (*Merops ornatus*)	Mi; S3	The Rainbow Bee-eater is a common breeding migrant that occurs widely across much of Australia and in Western Australia, from the Kimberley and Pilbara through to the southwest (Johnstone & Storr, 1998). It generally breeds in summer in the greater southwest and occurs as a passage migrant or visitor in the northern part of its range throughout the rest of the year (Johnstone & Storr, 1998; Barrett et al., 2003). It occurs in lightly wooded, often sandy country, preferring areas near water. The Rainbow Bee-eater feeds on airborne insects, and nests in burrows excavated in sandy ground or in banks of creeks and rivers (Johnstone & Storr, 1998).	There are 659 records of the Rainbow Bee-eater from within the vicinity of the study area (DEC, 2012e). The records are dated from 1902 to 2012 (DEC, 2012e). All the habitat types in the survey area provide habitat for the Rainbow Bee-eater, in particular the soft substrates which provide potential nesting sites. The Rainbow Bee-eater is likely to occur in the study area.	Likely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
MAMMALS				
Chuditch/Western Quoll (*Dasyurus geoffroii*)	Vu; S1	The Chuditch once occupied over 70% of Australia, but is now restricted to the southwest of Western Australia (van Dyck & Strahan, 2008). Being a relatively large predator, it occurs at low densities. Adult females inhabit a core area of 55-200 ha and males 400 ha (van Dyck & Strahan, 2008). The Chuditch is now only found in sclerophyll forest, woodland and mallee shrubland (Menkhorst & Knight, 2004; van Dyck & Strahan, 2008).	Thirty-four records of the Western Quoll are known from the vicinity of the study area (DEC 2012e). The most recent record 2011 comes from Martin, approximately 15 km northeast on the Darling Scarp. All recent records are situated to the east of the study area. The study area lacks suitable woodland habitat and as such no hollows (no potential den sites) means this species is unlikely to occur within the survey area.	Unlikely
Wambenger/Southern Brush-tailed Phascogale (*Phascogale tapoatafa* ssp. (WAM M434)	S1	The Wambenger is an undescribed subspecies of the Brush-tailed Phascogale that occurs in south-west Western Australia (van Dyck & Strahan, 2008; Peter Mawson *pers. com*. [DEC]). It is restricted to the extreme southwest, and its characteristic low population densities make it vulnerable to localised extinction (van Dyck & Strahan, 2008). This subspecies occupies dry sclerophyll forests and open woodlands containing hollow-bearing trees with a sparse ground cover. Habitat destruction, in particular, the loss of hollow-bearing trees and predation by feral animals, are thought to be the major threats to surviving populations (DEC, 2006).	There are 17 records of the Southern Brush-tailed Phascogale from within the vicinity of the study area (DEC 2012e). Records span from 1960 to 2007 and situated to the east of the study area, on the Darling Scarp where there is a greater amount of tall trees with hollows (DEC 2012e). The study area does not contain any hollow bearing trees and is not deemed suitable habitat for the Southern Brush-tailed Phascogale.	Highly Unlikely
Numbat (*Myrmecobius fasciatus*)	Vu; S1	The Numbat is a small, diurnal marsupial, endemic to WA. This species once ranged widely but due to predation by foxes and cats, loss of habitat and changes in fire regimes, have contracted substantially (van Dyck & Strahan, 2008). Its current distribution is limited to east of Manjimup in upland Jarrah forests, open eucalypt woodlands, *Banksia* woodlands and tall closed shrublands, where it shelters in hollow logs and branches and feeds almost exclusively on termites (van Dyck & Strahan, 2008).	There are 17 records of the Numbat situated within the vicinity of the study area (DEC 2012e). Records are likely to be old given that the species has significantly declined and the current distribution of this species is far outside of the study area (van Dyck & Strahan, 2008). Furthermore the study area contains no habitat suitable for Numbat i.e. hollow logs etc.	Highly Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Quenda, Southern Brown Bandicoot (*Isoodon obesulus*)	P5	The Quenda occurs in forest, heath and coastal scrubs along the coast of south-western WA from Moore River to Israelite Bay (Menkhorst & Knight, 2001). They typically seek daytime refuge from predators in very thick ground-storey vegetation, often associated with swamps or damplands (Long, 2009). They forage by night in open areas, leaving distinctive conical feeding holes in the ground (Long, 2009). The Quenda is threatened by clearing and fragmentation of its preferred habitat (van Dyck & Strahan, 2008).	There are 743 records of the Quenda from within the vicinity of the study area, most of which are recent (DEC 2012e). The study area and surrounding bushland provides ideal habitat for the species. There is sandy substrate and a good amount of understorey vegetation. The distinctive conical feeding holes and prints were recorded during the survey.	Recorded (from secondary evidence)
Woylie, Brush-tailed Bettong (*Bettongia penicillata*)	En; S1	The Woylie occupies sclerophyll forests and mallee eucalypt woodlands with a dense low understorey of tussock grasses (van Dyck & Strahan, 2008). Once distributed across much of mainland Australia, the species is now confined to three populations in southwest WA, Dryandra Woodland, Tutanning Nature Reserve and Perup Forest (Yeatman & Groom, 2012). Their diet consists largely of underground fungi, tubers, bulbs and grain/seeds (van Dyck & Strahan, 2008)	There are three records of the Woylie located within the vicinity of the study area (DEC, 2012e). The most recent comes from Norma Road Bushland in Whitby. The Woylie has experienced severe declines since European settlement and the species is now confined to a small number of conservation reserves within the southwest. The habitats present within the study area are not suitable to support the species.	Highly Unlikely
Tammar Wallaby (*Macropus eugenii*)	P5	In south-western Western Australia numbers of the Tammar Wallaby have been reduced primarily as a result of land clearing (van Dyck & Strahan, 2008). The Tammar requires dense low vegetation for daytime shelter and open grassy areas for foraging (van Dyck & Strahan, 2008). This species inhabits coastal scrub, heath, dry sclerophyll forest and thickets in mallee woodland (van Dyck & Strahan, 2008).	There is one record of the Tammar Wallaby from the Harry Waring Marsupial Reserve, the record is from 1971 (DEC, 2012e). The Tammar Wallaby has undergone declines since European settlement as a result of extensive land clearing and is now restricted to areas east of the Darling Scarp as well as small offshore islands (Abbott, 2008). The habitats present in the study area are not considered suitable for the species.	Highly Unlikely

Conservation Significant Species	Conservation Status	Distribution and Ecology	Habitat Relevance	Likelihood
Western Brush Wallaby (*Macropus Irma*)	P4	The Western Brush Wallaby occurs in open forest or woodland, particularly in areas where grassy understorey and scrubby thickets are present (van Dyck & Strahan, 2008). It is found only in south-western Western Australia where it appears to be in decline as a result of an increase in the numbers of foxes which results in greater rates of predation (van Dyck & Strahan, 2008).	There are 33 records of the Western Brush Wallaby from within the vicinity of the study area (DEC, 2012e). Over half the records come from the native bushland surrounding Jandakot Airport (2011). The melaleuca shrublands and banksia woodland of the study area both provide suitable habitat for the species, although the species is not widespread and uncommon within the Perth metropolitan area.	Possible
Quokka (*Setonix brachyurus*)	VU; S1	The Quokka is found in the south-west regions of Western Australia, from south of Perth in Jarrah, Marri and Karri Forest to Two People's Bay (Menkhorst & Knight, 2001). It mostly occurs in densely vegetated swamps, tea tree thickets on sandy soils along creek lines and dense heath on slopes (van Dyck & Strahan, 2008). Quokka numbers have declined because of predation by foxes and the clearing and burning of swamp habitats (van Dyck & Strahan, 2008).	There are 24 records of the Quokka from the vicinity of the study area (DEC, 2012e). Records are dated from 1958 with most coming from Byford and Roleystone, just south of the study area in 2010/11. The species tends to prefer habitats with a dense understorey. The study does not provide ideal habitat for the species but furthermore the study area is situated within a fragmented landscape that restricts movements of individuals and is likely to be exposed to predators such as foxes and cats which are a major cause of population decline for this species.	Unlikely
Western False Pipistrelle (*Falsistrellus mackenziei*)	P4	The Western False Pipistrelle prefers Karri forest, wetter stands of Jarrah and Tuart, and Corymbia woodlands. The Western False Pipistrelle roosts in tree hollows and forages mainly at canopy level (van Dyck & Strahan, 2008). The major threat to this species is the loss of feeding grounds and suitable habitat to forestry and clearing for agriculture.	There is one record of the Western False Pipistrelle from within the vicinity of the study area. The record is of a capture from the Harry Waring Marsupial Reserve in Jandakot, 1993 (DEC, 2012e). The study area provides no roosting habitat for the species i.e. no tree hollows. However the species is highly mobile and may possibly occur across the study area when foraging.	Possible

Key:	
En	Listed as Endangered under the *EBPC Act 1999*.
Vu	Listed as Vulnerable under the *EBPC Act 1999*.
Mi	Listed as Migratory under the *EBPC Act 1999*.
S	Scheduled under the *WC Act 1950*. Schedule 1 and 2 fauna are also protected by the *EBPC Act 1999*.
P	Listed as Priority by the DEC.
Recorded	Recorded during the field survey or site reconnaissance.
Likely	Suitable habitat is present in the study area and the study area is in the species' known distribution.
Possible	Limited or no suitable habitat is present in study area but is nearby. The species has good dispersal abilities and is known from the general area.
Unlikely	No suitable habitat is present in study area but is nearby, the species has poor dispersal abilities, but is known from the general area; or suitable habitat is present, however the study area is outside of the species' known distribution.
Highly Unlikely	The species has poor dispersal abilities, no suitable habitat is present, and the species is uncommon; or the species is thought to be locally extinct.

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Appendix E

Draft Acid Sulfate Soil and Dewatering Management Plan

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Water Corporation

Keane Road Pressure Main, Balannup

Draft Acid Sulfate Soil and Dewatering Management Plan

April 2014

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Appendices

1. Introduction

1.1 Project Background

The Water Corporation (WC) is proposing an M&E upgrade of the Balannup Wastewater Sewerage Pump Station (WWPS) and to construct a new rising pressure main along Keane Road to the Waterworks Road WWPS in Haynes, 22km south of Perth in Western Australia. The site locality is depicted on Figure 1. The construction upgrade will be undertaken in a phased approach and Stage 1 (the remit of this ASSDMP) will comprise the following tasks:

1. **Section 1**: Construction of approximately 1km (Chainage (Ch) 0 to 1080) of pressure main at an assumed invert between 2m and 2.5m depth (Ch 0 to Ch 522) and 1m to 1.5m depth (Ch 522 to Ch 1080). The pressure main will commence at the existing DN375 pressure main located on Welcome Meander in Harrisdale to the start of Bush Forever area at the intersection of Skeet Road and Keane Road. The pressure main is anticipated to be installed utilising open excavation techniques.
2. **Section 2**: Installation of approximately 1.5km (Ch 1080 to 2600) DN450 PE pressure main at an invert level of 1.5m to 2m depth utilising trenchless methods (Eco-Ploughing) through the Bush Forever area to the Anstey Road and Keane Road intersection in Forrestdale.
3. **Section 3**: Construction of approximately 2km (Ch 2600 to Ch 4557) DN375 pressure main at an invert between 1m and 2m depth from the Anstey Road and Keane Road intersection to the Waterworks Road WWPS utilising open excavation techniques.
4. Three (3) road crossings have been identified during the installation; two (2) of these crossings will be undertaken utilising trenchless techniques, one (Anstey Road) will be open excavated. A DN450 PE100 pipe is anticipated to be installed for all road crossings outlined below at an invert between 3m and 3.5m depth.
    a. Armadale Road (trenchless);
    b. Tonkin Highway (trenchless); and
    c. Anstey Road/ Damper to Bunbury Natural Gas Pipeline (open excavation).

The general arrangement of the infrastructure outlined above is indicated in the GHD plan and longitudinal section drawings (i.e. Drawing No: HW91-085-01A1 to HW91-085-002-15A, Appendix B).

GHD was commissioned by Water Corporation to prepare an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP) based upon the recommendations of the geotechnical and acid sulfate soil (ASS) investigations performed as part of the geotechnical consulting services for the project.

The dewatering requirements have not yet been fully identified, and this document is therefore not considered to be the final ASS Dewatering Management Plan (ASSDMP). At the time of writing the detailed design has not been completed and the construction contractor procurement process has not yet commenced.

This document has been prepared using information available at the time of preparation (engineering design drawings). This document should be updated as additional information becomes available on construction elements requiring dewatering and dewatering designs are developed.

1.2 Purpose of this Document

This document and content has been prepared on a draft basis and requires to be finalised prior to the commencement of construction. The construction methodology and management strategies are based upon assumed construction methods and these methods are required to be finalised before the management strategies are valid and suitable for the works.

When finalised, the aim of this document is to summarise the results of the ASS and groundwater investigations and document the findings of those investigations (where relevant) to assist in the preparation of the ASSDMP. This document is considered to address the ASS management and dewatering requirements for the pressure main alignment.

This document addresses the key construction issues that may impact on groundwater, environmental receptors and groundwater users within the vicinity of the site and includes:

- A framework for the treatment and management of excavated/disturbed material defined as ASS during construction of the pressure main.
- A framework for management of dewatering effluent and groundwater, specifically with regards to managing the groundwater quality and levels, during development works.
- The likely depth to groundwater within the vicinity of the pressure main alignment and highlight areas, which may require dewatering; and
- An indication of further detailed groundwater investigation work required.

This document contains an ASSDMP that will be used to inform the Contractor constructing the proposed infrastructure and provide appropriate management and action criteria during the treatment and dewatering operations to minimise potential impacts to the local groundwater, surface water systems, ecology and other groundwater users.

This document should be read in conjunction with the following geotechnical, ASS and contaminated sites investigation report for the site. The document is referenced below:

- GHD, 2013. *Report on the Geotechnical, Acid Sulfate Soils and Contaminated Sites Investigation, Balannup A WWPS and Keane Road Pressure Main* (Document number 134551, Rev 0). November, 2013.

1.3 Scope and Limitations

This report has been prepared by GHD for Water Corporation and may only be used and relied on by Water Corporation for the purpose agreed between GHD and the Water Corporation as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that and any recommendations in this report are based on conditions encountered and the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report where and as they are required. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Water Corporation and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

Site conditions (including the presence of hazardous substances and/or site contamination) may change after the date of this Report. GHD does not accept responsibility arising from, or in connection with, any change to the site conditions. GHD is also not responsible for updating this report if the site conditions change.

2. Background information

2.1 Acid Sulfate Soil

The classification of ASS includes both actual acid sulfate soils (AASS) and potential acid sulfate soils (PASS). AASS are soils that are generating acidity and may still have residual potential acidity, whereas PASS are soils that have the potential to generate acidity.

ASS are soils containing naturally-occurring, fine-grained metal sulfides typically pyrite (FeS_2), formed under saturated, anoxic/reducing conditions. They generally occur in Quaternary (1.8 Ma – Present) marine or estuarine sediments, predominantly confined to coastal lowlands (elevations generally below 5 m Australian Height Datum (AHD)). Within these sediments, the majority of soils that present an environmental risk are generally confined to Holocene aged material (<10 000 years). Where these materials have oxidised, they commonly have a mottled appearance (orange and yellow discolouration) due to the presence of oxidised iron minerals.

Although soils described above represent typical conditions where ASS occurs, the presence of ASS materials is not limited to these soil types. In Western Australia, ASS materials have been identified in other soil types such as leached sands and silts. Accordingly, for areas where no data is available, the extent of ASS materials should be established through field investigations.

2.2 Potential Risks of AASS and PASS

When PASS are disturbed, either by excavation or lowering of the water table below natural seasonal levels, sulfides present are exposed to air, allowing oxidisation and consequently, the formation of sulfuric acid (H_2SO_4). AASS are capable of generating acidity *in situ* in their natural state; disturbance is not required for acidic discharges to develop.

As a result of the presence of AASS, or the oxidation of PASS, surrounding land (soil) and nearby waterways may become acidic (pH<6.5). Under acidic conditions, metals such as aluminium (generally at pH<4.5) and iron, as well as trace heavy metals (including arsenic), become more mobile in the environment and can be taken up by infiltrating waters.

Disturbance of ASS impacted areas may release hydrogen sulfide gas which typically settles within confined spaces and excavations such as trenches and/or depressions. Hydrogen sulfide gas has the potential to reach toxic levels and appropriate occupational health and safety measures may require to be implemented within areas of depressions and/ or during excavation of confined spaces.

2.3 Potential Effects of Dewatering Groundwater

2.3.1 Water Quality

Dissolved metals including iron and aluminium may cause environmental issues, if the dewatering effluent is discharged prior to retention. Discharge without retention may cause iron hydroxides to precipitate out where effluent is discharged into water bodies (particularly surface water). These chemical reactions may release large quantities of acid and consume oxygen causing de-oxygenation of the water column in nearby ecosystems or the local groundwater system and decreasing local buffering capacity (alkalinity), where available. In cases where alkalinity can no longer buffer acidity, then acidification of the groundwater may occur.

Acidic conditions generated by ASS can also corrode concrete and steel (pipes, bridge abutments, underground services, and other infrastructure) and can result in the rapid deterioration of asphalt surfaces where they overlie AASS or PASS. Acidic groundwater plumes can impact on vegetation health of deep rooted vegetation, and affect the water quality of any

downstream groundwater receptors including surface water bodies and domestic and industrial water supply bores.

2.4 Management

2.4.1 Management of ASS

Avoiding or minimising disturbance of ASS is the primary methods of management. Where avoiding disturbance is not possible, management techniques available for ASS can include:

- Chemical neutralisation (use of pure fine agricultural lime (AgLime) or a similar neutralising agent).
- Anoxic storage or placement of PASS below the water table and beneath clean non-ASS fill; and
- Hydraulic separation of pyrite from the soil (high maintenance process suitable for coarse grained sediment).

The addition of agricultural lime is the most common amelioration technique applied to acidic soils, where mechanical mixing is completed by plough or excavator to provide adequate homogeneity of the soil/sediment-lime mix.

2.4.2 Management of Dewatering Effluent

The groundwater conditions at the site are indicative of an area which may be vulnerable to acidification and therefore the risk of the water quality impacts outlined within Section 2.3.1 occurring is high. Dewatering operations should be undertaken with appropriate management measures, monitoring trigger actions and contingency strategies to prevent the degradation of groundwater during construction.

The management strategies implemented within this document are in accordance with the appropriate legislative requirements and guidelines outlined within Section 2.5.

2.5 Legislative Requirements in Western Australia

The following legislative requirements may apply to works involving dewatering activities:

2.5.1 Western Australian Planning Commission Bulletin 64/2009

The recently amended *Planning Bulletin 64/2009 (PB 64/09)* aims to provide advice and guidance on matters that should be taken into account in the rezoning, subdivision and development of land containing acid sulfate soils. PB 64/09 requires the identification, assessment and management of soils where:

- The surface elevation is ≤ 5m AHD, and it is proposed to excavate ≥ 100m^3 of soil;
- Where the surface elevation is ≥ 5m AHD, and it is proposed to excavate ≥ 100m^3, and the excavation depth is ≥ 2m; or
- Where any dewatering works are to be undertaken.

2.5.2 Environmental Protection Act 1986

The *Environmental Protection Act 1986* (EP Act 1986) provides for an Environmental Protection Authority, for the prevention, control and abatement of pollution and environmental harm, for the conservation, preservation, protection, enhancement and management of the environment and for matters incidental to or connected with the foregoing.

To prevent environmental harm, the EP Act 1986 established under Section 50A, states that:

A person who –

a. causes serious environmental harm; or

b. allows serious environmental harm to be caused - commits an offence.

Accordingly, all parties to a development must show that the environmental risk associated with the development has been assessed and minimised where possible.

2.5.3 Rights in Water and Irrigation Act (1914)

In accordance with the '*Water Corporation Acid Sulfate Soil and Dewatering Management Strategy'* (Water Corporation, July 2007) the Water Corporation is not required to obtain either a Section 5C or Section 26D license under the Rights in Water and Irrigation Act (1914) in regards to dewatering. The power given to the Water Corporation by Section 83(2)(b) of the Water Agencies (Powers) Act 1984 overrides the generic requirements of Sections 5C and 26D of the Rights in Water and irrigation Act and therefore the Water Corporation is exempt from the requirement to obtain a dewatering license.

3. Site Characterisation

The information presented below has been abstracted from the geotechnical and acid sulfate soil and contaminated sites investigation report (GHD, 2013) and has been utilised to assist with the preparation of this ASSDMP.

3.1 Site Description and Topography

3.1.1 Section 1: Ch 0 to C 1080

Section 1 extends from the north west corner of the project area in Harrisdale to Skeet Road. The pressure main will connect to an existing pressure main within a recently developed subdivision (Heron Park).

This portion of the alignment gently declines in elevation from the initial starting point at Turtledove Road to the Bush Forever Area located at the intersection of Skeet Road and Keane Road. Elevation typical ranges between 26.5m AHD to 25.6m AHD.

3.1.2 Section 2: Ch 1080 to Ch 2600

Section 2 extends the length of the Bush Forever designated land (Figure 1). Section 2 is characterised by a loose sandy track approximately following the Keane Road reserve alignment. The track is boarded on either side by scrub which becomes less dense towards the east. At the far east of the Bush Forever area the scrub gives way to grass/weeds along a Water Corporation easement.

The Bush Forever area typically gently slopes north west to south east with elevations ranging from 25m AHD to 22.2m AHD. The south eastern end of the road reserve track was characterised by standing water covering most of the track during the investigation undertaken in June and July 2013. Freestanding water to approximately 0.5 m was observed from approximately Ch. 2170 to Ch. 2600 during this period.

3.1.3 Section 3: Ch 2600 to Ch 4557

Section 3 between Ch. 2600 and Ch. 4557 extends along the south east continuation of Keane Road and into Hanlin Road beyond the Armadale Road intersection before crossing Tonkin Highway and terminating within the Water Corporation depot at the WWPS.

The proposed pressure main terminates inside the Water Corporation depot at the waterworks site. The Water Corporation grounds between Tonkin Highway and the waterworks generally consist of sandy tracks, defined by derelict wire fences and low lying grasses and shrubs. The waterworks and surrounding infrastructure are located within a paved area bordered by trees.

Elevation from the Bush Forever area typically inclines from Anstey Road to the Tonkin Highway with a few gently undulations. Elevation ranges from 22.2m AHD to 25.2m AHD, with the undulations to a minimum of 23.5m AHD. Elevation at the WWPS is typically 27.3 mAHD.

3.2 Climate

The Gosnells area (closest weather station with long-term recording information within the proximity to Armadale) has a Mediterranean climate of cool, wet winters and hot, dry summers. Climatic information collected from the Gosnells meteorological monitoring station is presented in Table 1.

Table 1 Climatic information

Station	Mean Annual Minimum Temperature Range (ºC)	Mean Annual Maximum Temperature Range (ºC)	Annual Rainfall (mm)
Gosnells City (09106)	17.3 (July) – 30.5 (Jan.)	20.1 (July) – 36.3 (Feb.)	640.0[1]

Source: Bureau of Meteorology Climatic Averages of Australian Sites, 2014.

3.3 Regional Geology

3.3.1 Published Information

The 1:50,000 Environmental Geology Series "*Armadale*" Part Sheets 2033 1 and 2133 IV indicate that the site is predominantly underlain by the Bassendean Sand unit (as indicated in Figure 2). Bassendean Sand is described as a *'white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin'*. A thin layer of friable variably cemented iron and/or organic rich sands colloquially known as 'coffee rock' is commonly encountered within the vicinity of the water table.

Coffee rock forms by the precipitation of humates and iron from groundwater, mainly in the zone of water table fluctuations, and may vary between bright orange, orange brown and dark brown to black. Coffee rock horizons contain stored potential acidity in a number of forms including inorganic sulfides such as di-sulfides (pyrites) and poorly crystalline and easily hydrolysable iron and manganese oxides.

The Bassendean Sand is underlain at variable depth by alluvial clayey, silty and sandy soils of the Guildford Formation. The Guildford Formation consists of clay, sand and gravel and is variably laterised and podsolised.

Small pockets of peaty clay associated with swamps (subject to seasonal flooding) are likely to be encountered at or near surface to the south east of Skeet Road. The peaty clay found in this region is formed from swamp deposits and is described as '*grey to black, fine to medium grained, moderately sorted quartz sand, slightly peaty of lacustrine origin'*.

3.3.2 Site Specific Ground Conditions

The soils intersected during execution of the geotechnical site investigation are generally consistent with the 1:50,000 Environmental Geology map for the region. The local ground conditions along the pressure main alignment where ASS and/or dewatering management is required is described in Table 2.

[1] Annual rainfall for 2012, rainfall data for 2013 not available.

Table 2 Summary of Site Specific Ground Conditions

Section	Chainage	Subsurface Conditions	Depth (m bgl)
Section 1	0 to 1080	Topsoil: black/brown medium grained sand.	0.1 – 0.2 m
		Fill: pale yellow/brown sand with fine to medium grained limestone gravel.	0.9 – 3.5 m
		Bassendean Sand: grey/brown poorly graded sand.	Max. 3.3 m
		Guildford Formation: black medium grained silty sand/sand with gravel and weakly iron cemented clasts.	>3.5 m
Section 2	1080 to 1400	Bassendean Sand: grey to brown, fine to medium grained, poorly graded sand with trace organics.	1.5 – 2.5 m
		Guildford Formation: dark brown/black, low plasticity silty sand/sandy silts.	1.5 – 3.0 m
	1400 to 2600	Bassendean Sand: grey to brown, medium grained, poorly graded sand with trace organics.	0.5 – 2.0 m
		Guildford Formation: grey/brown clayey sand, medium grained.	>2.0 m
Section 3	2600 to 4557	Fill: pale yellow/brown sand with fine to medium grained gravel.	0 - 0.5 m
		Bassendean Sand: grey/white fine to medium grained poorly graded sand, trace organics and silt.	0 – 3.4 m
		Guildford Formation: grey to brown with medium grained sand.	>0.7 m

3.4 Regional Groundwater

The Hydrogeological Atlas of Western Australia indicates two aquifers in the area, Perth Superficial Swan and Leederville Aquifer. The Bassendean Sand geological units make up the superficial aquifer within the study area. The Leederville Aquifer is deep relative to the proposed construction and is not relevant to this ASSDMP.

Review of the Department of Water's Perth Groundwater Atlas provides information in regards to the groundwater level (May, 2003) and the historical maximum groundwater levels for the pressure main alignment. Table 3 below summarises this information.

Table 3 Summary of Groundwater

Section	Chainage	May (2003) (m AHD)	Historical maximum (m AHD)
Section 1	0 to 1080	23.5 to 22.5	25.5 to 24.5
Section 2	1080 to 2600	23.0 to 21.0	25.0 to 23.0
Section 3	2600 to 4557	21.0 to 22.0	23.0 to 25.0

The Perth Groundwater Atlas historical maximum contours are presented on Figure 3, along with the groundwater monitoring data obtained during the monitoring program in August, 2013.

3.4.1 Site Specific Groundwater

Groundwater was encountered along the pressure main alignment during the June/July 2013 site investigation and the groundwater monitoring program in August 2013. Groundwater levels were estimated during the geotechnical investigation using groundwater depth data and estimates of surface elevations obtained from contour data are presented below.

The information below presented the maximum and minimum groundwater levels observed for each alignment section.

- Section 1 - 23.5 m AHD to 25.2 m AHD;
- Section 2 - 19.5 m AHD to 24 m AHD; and,
- Section 3 - 20 m AHD to 23.2 m AHD.

3.5 ASS Risk Mapping

Review of the Department of Environment Regulation (DER), formerly Department of Environment and Conservation (DEC) ASS risk mapping available through the Landgate Shared Land Information Portal (SLIP) indicates that the majority of the alignment overlies an area of *'Moderate to low risk of ASS occurring within 3 m of natural soil surface but high to moderate risk of ASS beyond 3 m of natural soil surface*'. Additionally there are three small areas of '*High to moderate risk of ASS occurring within 3 m of natural surface soil'*. These areas correspond to the following chainages:

- Section 2: Chainage 1640 – 1780;
- Section 2: Chainage 2445 – 2653; and
- Section 2: Chainage 2305 – 3612.

These areas are associated with peaty clay (Cps) sediments as depicted on the published geological information and were also targeted during the geotechnical site investigation.

The ASS risk and the environmental constraints for the pressure main alignment are presented on Figure 4.

4. Summary ASS Investigation

4.1 Background Investigation Information

In consideration of the moderate risk of ASS, a site walkover, visual assessment and site investigation was undertaken in conjunction with the geotechnical investigation. The site works were undertaken in accordance with the Water Corporation *Acid Sulfate Soil and Dewatering Management Strategy*, prepared by Parsons Brinkerhoff (Rev. C, July 2007).

The site investigation was undertaken in conjunction with the geotechnical and contamination investigation in June and July 2013 to establish the ASS risk within the footprint of the proposed works and the risk associated with potential dewatering operations associated with construction.

Additionally, a review of photographs obtained from the geotechnical investigation (where available) and logs were undertaken to identify any additional ASS indicators.

4.2 Summary of Results

The ASS investigation is reported within the geotechnical and ASS investigation report (GHD, 2013) and the below information provides a summary of the results obtained. The site investigation results are provided with Table 1, Appendix C for information purposes and to assist with the preparation of this ASSDMP. The investigation locations are provided on Figure 5.

ASS was identified in samples collected from fifteen (15) of the twenty eight (28) push probing locations drilled during the site investigation. PASS material is associated with the black silty sands, grey silty/clayey sands, black/brown sandy silt and coffee rock horizons, generally at or below the water table.

The maximum inferred RL of PASS encountered during the investigation was 23.5 m AHD within the brown silty sand horizon at BH15, located within the Bush Forever section.

Based on the proposed pipeline invert levels, it is likely that ASS material will be disturbed as part of the construction works. An Acid Sulfate Soil Management Plan (ASSMP) will be required prior to commencing earthworks to guide the treatment and management of ASS material during construction.

5. Summary of Groundwater Investigation

The groundwater investigation was undertaken as part of the geotechnical, ASS and contaminated sites investigation in August 2013 and is reported within the geotechnical and ASS investigation report (GHD, 2013), however to assist with the preparation of this ASSDMP, the groundwater investigation has been outlined below.

5.1 Groundwater Monitoring Locations

The groundwater monitoring well locations are presented in Figure 6 and summarised in Table 4.

Table 4 Borehole Summary Information

BH ID	Chainage	Co-ordinates		Elevation (m AHD)	Depth achieved (m)	Groundwater August 2013 (mAHD)
		Easting	Northing			
BH01	47	398909	6445341	26.80	3.45	25.20
BH03	570	399047	6444936	27.00	3.45	25.20
BH06 North	2,667	400565	6443495	22.00	6.00	21.20
BH06 South	2,674	400563	6443483	22.50	6.45	21.90
BH08	3,161	400922	6443153	24.25	2.80	22.60
BH10	3,665	401281	6442799	23.40	4.50	23.20
BH11	3,853	401414	6442667	23.50	4.50	22.10
BH12	4,199	401666	6442408	23.75	4.50	22.80
BH13	4,395	401821	6442405	24.75	4.50	22.50
BH16	1,396	399664	6444386	24.40	6.00	No access
BH19	1,685	399869	6444183	23.90	6.00	No access
BH22	2,000	400097	6443966	23.80	6.00	No access
BH25	2,293	400303	6443757	22.75	6.00	No access
BH28	3,553	401204	6442881	23.25	3.00	22.10

It should be noted that due to the ongoing dewatering being carried out to facilitate construction works at the Exchange Road end of the Harrisdale subdivisional site works the groundwater levels observed in BH04 may not give a true representation of natural groundwater levels.

5.2 Groundwater Laboratory Program

Laboratory testing of groundwater samples was carried out by Australian Laboratory Services (ALS), a National Association of Testing Authorities (NATA) accredited environmental laboratory based in Malaga, Perth.

Samples were submitted for the following analytes:

- Acidity, pH, electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS);
- Major anions (Cl, SO_4, alkalinity);
- Major cations (Ca, Mg, Na, K);
- Dissolved metals (Al, As, Cd, Cr, Fe, Mn, Ni, Se, Zn);
- Total metals (Al, Fe);
- Nutrients (nitrogen and phosphorus); and
- Sulfide.

5.3 Groundwater Assessment Criteria

The following assessment criteria have been adopted for a preliminary assessment of pre-existing contamination (if present) and ASS groundwater indicators at the Site and are referred to in the DER Assessment Levels for Soil Sediment and Water (DEC, 2010, Version 4.1).

- Fresh Water
- Short Term Irrigation (STI)
- DER ASS indicator criteria

5.3.1 Freshwater Guidelines

Guidelines for the protection of ecological receptors are provided in Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000), and adopted by DER in Assessment Levels for Soil, Sediment and Water (DEC, 2010, Version 4.1).

The site is located within the vicinity of natural wetland receptors and the freshwater guidelines are considered appropriate criteria to determine whether dewatered effluent may have a detrimental effect on the wetland water quality. The freshwater guidelines present various assessment criteria depending upon the surrounding environs. It is considered for this site that where more than one assessment criterion has been made available, the Wetland values will be selected.

5.3.2 Short Term Irrigation Water Guidelines

In consideration of the potential for infiltration to be used as a method for dewatering effluent disposal, groundwater quality was compared to the STI guidelines specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ, 2000).

5.3.3 DER ASS Indicator Criteria

The DER ASS Guideline Series (DEC, 2013) outline chemical indicators that may indicate the groundwater is being affected by, or has already been affected by, the oxidation of sulfides. These indicators are outlined below.

- An alkalinity: sulfate ratio of less than 5 (Swedish EPA, 2002);
- A pH of less than 5 and/or
- A soluble aluminium concentration greater than 1 mg/L.

It should be noted that the above criteria are indicators only and do not necessarily denote that the oxidation of ASS materials has occurred. Any exceedence of the criteria should be identified and compared to other analytes prior to drawing conclusions on ASS.

Additional groundwater assessment criteria (adopted by the DER from the Swedish EPA), relate alkalinity with pH and infer the potential buffering capacity of groundwater. The assessment guide for the buffering capacity of groundwater is provided in Table 5.

Table 5 Assessment Guide for Buffering Capacity of Groundwater

Class	Designation	Alkalinity (mg/L)	pH	Description
1	Very high alkalinity	>80	>6.5	Adequate to maintain acceptable pH level in the future.
2	High alkalinity	60-80	>6.0	Adequate to maintain acceptable pH level in the future.
3	Moderate alkalinity	30-60	5.5-7.5	Inadequate to maintain stable, acceptable pH level on areas vulnerable to acidification.
4	Low alkalinity	10-30	5.0-6.0	Inadequate to maintain stable, acceptable pH level.
5	Very low alkalinity	<10	<6.0	Unacceptable pH level under all circumstances.

Table 5 Adapted from Swedish EPA, 2002.

5.4 Groundwater Quality Results (August 2013)

5.4.1 Water Quality Field Parameters

Groundwater sampled from the monitoring well was generally brown, turbid and with a slight organic odour.

The following general water quality parameters were noted:

- pH values presented ranged from 5.69 to 7.68 and is indicative of acidic to near neutral conditions.
- EC values presented ranged from 0.169 mS/cm to 21.0mS/cm and are indicative of fresh water to brackish conditions.
- Temperature values presented ranged from 17.14º C to 21.72 ºC.
- Dissolved oxygen values presented ranged from 0.59mg/L to 6.12mg/L.

5.4.2 Laboratory Results

The laboratory results and the NATA endorsed final laboratory reports are available in the geotechnical and ASS investigation report (GHD, 2013). The groundwater results are provided in Table 2, Appendix C.

Laboratory results indicate that groundwater chemistry varies along the alignment:

- pH ranges from 5.83 (BH08, Ch 3161) to 7.84 (BH11, Ch 3853);
- EC ranges from 173 µS/cm (BH08, Ch 3161) to 20,800 µS/cm (BH28, Ch 3553);
- Acidity ranges from 20 mg/L $CaCO_3$ (BH11, Ch 3853) to 113 mg/L $CaCO_3$ (BH03, Ch 570);

- Alkalinity (present as bicarbonate) ranges from 11 mg/L $CaCO_3$ (BH08, Ch 3161) to 415 mg/L $CaCO_3$ (BH06 North, Ch 2667); and
- Sulfate concentrations range from 23 mg/L (BH08, Ch 3161) to 727 mg/L (BH28, Ch 3553).

DER ASS Indicator Criteria

The following groundwater indicators were noted:

- Seven of the samples recorded alkalinity:sulfate ratios < 5. These include: BH01, BH03, BH06 North, BH08, BH10, BH11, BH12, BH13 and BH28. The remaining samples collected from BH10 and BH11 contain alkalinity:sulfate ratios > 5.
- None of the groundwater samples present pH value < 5
- None of the groundwater samples present soluble aluminium concentrations > 1 mg/L.
- Acidity ranges from 20 mg/L CaCO3 (BH11, Ch 3853) to 113 mg/L CaCO3 (BH03, Ch 570);

It should be noted that the above criteria are indicators only and do not necessarily denote that the oxidation of ASS materials has occurred. Any exceedance of the criteria should be identified and compared to other analytes prior to drawing conclusions on ASS.

ANZECC and ARMCANZ (2000) Fresh Water Ecosystem Protection Guideline

The following heavy metal concentrations exceeding the adopted assessment criteria were noted:

- Total aluminium concentrations exceeded the criteria (0.027 mg/L) in all nine (9) wells with exceedances ranging from 0.51 mg/L (BH01) up to 540 mg/L (BH13);
- Dissolved aluminium concentrations exceeded the criteria (0.027 mg/L) in seven (7) wells - BH01 (0.08 mg/L), BH03 (0.35 mg/L), BH06 North (0.11 mg/L), BH08 (0.2 mg/L), BH10 (0.85 mg/L), BH12 (0.81 mg/L) and BH13 (0.04 mg/L);
- Dissolved chromium concentrations exceeded the criteria (0.00001 mg/L) in five (5) wells – BH06 North (0.005 mg/L), BH08 (0.002 mg/L), BH10 (0.001 mg/L), BH12 (0.004 mg/L) and BH28 (0.006 mg/L);
- Dissolved copper concentrations exceeded the criteria (0.001 mg/L) in seven (7) wells – BH01 (0.002 mg/L), BH08 (0.002 mg/L), BH10 (0.005 mg/L), BH11 (0.003 mg/L), BH12 (0.006 mg/L), BH13 (0.002 mg/L) and BH28 (0.006 mg/L);
- Dissolved lead concentrations exceeded the criteria (0.001 mg/L) in two (2) wells – BH01 (0.002 mg/L) and BH12 (0.004 mg/L);
- Dissolved manganese concentrations exceeded the criteria (1.2 mg/L) in one (1) well – BH28 (1.5 mg/L);
- Dissolved nickel concentrations exceeded the criteria (0.008 mg/L) in one (1) well – BH28 (0.021 mg/L); and
- Dissolved zinc concentrations exceeded the criteria (0.0024 mg/L) in five (5) wells – BH03 (0.007 mg/L), BH08 (0.025 mg/L), BH10 (0.008 mg/L), BH12 (0.008 mg/L) and BH28 (0.024 mg/L).

No exceedances were recorded for dissolved arsenic, cadmium, cobalt or selenium concentrations in the nine (9) groundwater wells monitored.

Short Term Irrigation Water Guidelines

The following total metal concentrations exceeding the adopted assessment criteria were noted:

- Total aluminium concentrations exceeded the STI criteria (20 mg/L) in four (4) wells – BH06 North (68.7 mg/L), BH10 (184 mg/L), BH12 (26.1 mg/L) and BH13 (540 mg/L); and
- Total iron concentrations exceeded the STI criteria (10 mg/L) in four (4) wells – BH06 North (32.1 mg/L), BH10 (52.6 mg/L), BH11 (18.5 mg/L) and BH12 (76 mg/L).

6. Acid Sulfate Soil Management Plan

The management strategies outlined below and within the Flow Chart 1 will be required to ensure that there are no adverse impacts to sensitive environmental receptors within the vicinity of the site. The management practices below will be implemented to ensure that soils identified as ASS are managed accordingly.

As the tender for earthworks has not yet been awarded, the following text includes generic terms for the parties that will be involved, as defined below.

- *Contractor:* Contractor to be appointed by the Water Corporation.
- *Principal's Environmental Consultant:* Environmental consultant appointed by the Water Corporation.
- *Superintendent:* Supervising engineer appointed by the Water Corporation.

The Contractor will be responsible for ensuring that all management measures outlined in this section (or as agreed otherwise) are adhered to for the duration of their contract.

6.1 ASS Management Areas

The following ASS management areas are based on the ASS laboratory results obtained by GHD (2013) and the ASS management strategies are in accordance with the DER ASS Guideline Series (DEC, 2011) and the *Water Corporation Acid Sulfate Soil and Dewatering Management Strategy'* (Water Corporation, July 2007).

6.1.1 Topsoil

No ASS treatment or management of topsoils (0 - 0.3 m bgl) is necessary during construction.

For the purpose of this project, topsoil is defined as material up to the first 300 mm of the soil profile generally containing organic and vegetative matter. It is routine practice to remove the topsoil before excavation and stockpile until it is needed for top-dressing.

6.1.2 Defined ASS Areas

Table 6 below defines the areas within the pressure main alignment which are deemed to be ASS. Any soil material excavated from the areas outlined Table 6 must be managed in accordance with this section.

The treatment method for ASS has yet to be defined and therefore ASS management may be undertaken via off-site or on-site treatment operations. However due to space constraints, it is assumed that off-site disposal is the preferred management option. The sections below outline the requirements for off-site management.

6.1.3 Estimated ASS Volumes Requiring Treatment

The total volume of material excavated from the pressure main alignment will be dependent on the finalised method of construction. Table 6 below identifies the anticipated volume and type of material to be excavated.

Table 6 Defined ASS Areas and Estimated Volumes Requiring Treatment

Section	Chainage	Location Description	ASS	Lithological Description	Estimated Volume of ASS Material[2]
Section 1	819 to 1080	Exchange Ave to Skeet Rd	All material below 24m AHD or approximately 1.0m to 1.5m bgl	Guildford Formation: Black medium grained sand with traces of silt and clay (including weakly cemented clasts)	650m^3 Assumes 0.5m of material requiring treatment within trench excavations[3]
Section 2	1080 to 2600	Bush Forever Area	All material regardless of depth	Bassendean Sand: Grey to brown, fine to medium grained, poorly graded sand with trace organics underlain by Guildford Formation	Material disturbed however not excavated.
Section 3	4060 to 4400	South of Armadale Road to east side of Tonkin Highway	All material below 21.75m AHD or approximately 2.0m to 3.0m bgl	Guilford Formation: Pale brown/grey, medium grained clayey sand grading to dark grey/red brown silty sand	1750m^3. Assuming 1.0m of material requiring treatment within trench and from launch/receival pit[4] excavations

[2] Bulk density assumed at 1.6 t/m^3
[3] Trench is assumed to be 3m wide and of varying depth, typically 1m to 1.5m bgl.
[4] Launch/receival pits are assumed to be 5m (length) x 3m (wide) and approximately 1m greater depth than the invert level of the pressure main.

6.2 Treatment Option 1: Off-site Management (Transport to Licensed Facility)

6.2.1 Excavation, storage and transport offsite

Excavated ASS intended for off-site treatment will be dispatched to a licensed ASS treatment facility after excavation at the end of each excavation day.

Excavated soils not able to be dispatched at the end of each day must be stored on a limestone pad constructed to the requirements of Section 6.2.5 and should comply with the temporary storage requirements outlined in Section 6.2.4.

As a minimum, the ASS treatment facility must be provided with details of the materials they are being requested to accept (i.e. volume of material, predominant texture, the maximum net acidity value for the ASS material) which is contained in Table 7. Different facilities have varying information requirements before accepting material, and it is critical to ensure that acceptance of the material is approved prior to commencing excavation.

Table 7 Off-site Disposal Information

ASS Information (Treatment Facility)	
Material Type	**Section 1**: Black medium grained sand with traces of silt and clay (including weakly cemented clasts) **Section 3**: Pale brown/grey, medium grained clayey sand grading to dark grey/red brown silty sand
Maximum Net Acidity	**Section 1:** 220 mol H+/t **Section 3:** 36 mol H+/t
Indicative Liming Rate	**Section 1:** 35kg/m^3 (including Section 6.2.3) **Section 3: 6**kg/m3 (including Section 6.2.3)

Daily records must be kept of excavation and transport volumes, as well as records of receipt at the licensed facility.

6.2.2 Offsite Treatment: Summary of Reporting Requirements

The Contractor will prepare and maintain a daily log of all ASS material disposed off-site to the nominated licensed facility. Table 8 provides a summary of the reporting requirements.

Table 8 Summary of Reporting Requirements

	Action Item	Report to	Timeframe
Contractor	Letter of approval from the operators of the treatment facility indicating that they are aware of the nature of the soil they are receiving (i.e. ASS).	Superintendent & WC Environmental Officer	Prior to commencement of construction
Contractor	Daily log of all ASS excavated and transported offsite. Log to contain information of the location	Superintendent & WC Environmental Officer	Fortnightly during construction

	Action Item	Report to	Timeframe
	and volume of ASS removed, as well as transport destination(s).		
WC Environmental Officer	Inclusion of the letter of approval and ASS delivery receipts in the Initial Closure Report.	WC Project Manager (& DER if elected by WC Project Manager)	To be prepared within 4-6 weeks of completion of all earthworks and dewatering operations.

6.2.3 Neutralisation Rate for Excavated ASS

The Contractor should provide the following information to the licensed facility operator(s) prior to excavation.

The following uncorrected liming rate calculation assumes the following variables and is adopted from the DER ASS Guideline Series (DEC, 2013):

- Maximum Net Acidity (See relevant section along alignment) ;
- Safety Factor of 2.0;
- Conservative bulk density[5] of 1.6 t/m^3; and
- Effective Neutralising Value (ENV) of neutralising material is assumed to be 100%

Table 9 provides a summary of the neutralisation rate for the site.

Table 9 Calculated Neutralisation Rates

ASS Unit	Maximum Net Acidity Result	Assumed Bulk Density (tonne/m^3)	Uncorrected Liming Rate (kg/m^3)[6]
Section 1: Ch 819 to Ch 1080	0.35%S (220 mol H+/tonne)	1.6	35
Section 3: Ch 4060 to Ch 4400	0.06%S (36 mol H+/tonne)	1.6	6

6.2.4 Temporary Storage Time Restriction

Temporary storage of ASS onsite pending treatment off-site disposal may be for a maximum of fourteen (14) days.

Excavated ASS soils may be temporarily stockpiled pending off-site disposal on the bunded treatment pad. Based on the texture of the identified ASS material (worse case consists of sands with less than 5% clay content), temporary storage of ASS pending treatment may be for a maximum of fourteen (14) days.

6.2.5 ASS Storage and Treatment Area (Limestone Pad)

Excavated soils deemed to be ASS must be stockpiled on a bunded limestone treatment pad after excavation if transport to an off-site facility cannot be achieved at the end of each excavation day.

[5] Bulk density derived from GHD (2013)
[6] Uncorrected liming rate assumes Aglime has 100% ENV, liming rate to be corrected prior to construction.

The treatment/ holding pad will consist of the following components:

- Constructed of compacted crushed limestone of not less than 300mm in thickness. The pad shall be graded to ensure good drainage towards the back of the pad to ensure runoff and any leachate is collected within a lined stormwater collection basin.
- Three (3) sides will be bunded with limestone or similar alkaline material to a minimum height of approximately 150mm above the surface of the pad to prevent lateral run-off. A leachate collection and treatment system will also be required to manage run-off during winter periods or rainfall events.
- The stormwater collection basin should be lined with a low permeability liner (clay or synthetic). The leachate collection basin should be of sufficient size to retain the first 10mm of runoff from the bunded area, and should overflow to a separate unlined infiltration area or basin after treatment (if monitoring indicates treatment is required).
- Stockpiles should not exceed 2.5m in height.

The Contractor is to provide a description of their proposed methodology including the location of the proposed storage area, if required prior to the commencement of works. The method and location is to be approved by the WC Environmental Officer prior to the commencement of excavation and may require adjustment during works.

6.3 Treatment Option 2: Ch 1080 to Ch 2600 (Bush Forever Area)

The area within the Bush Forever area has been defined as containing ASS material within varying depth throughout the proposed pressure main alignment however is predominately located from between 1m and 1.5m bgl. ASS was detected within the termination depth of sample locations to a maximum depth of 6.45m bgl.

The Water Corporation has indicated that Eco-Ploughing through this area is considered their preferred option after consultation with the Department of Parks and Wildlife (DPaW) and Department of Environmental Regulation (DER) to preserve the Bush Forever area.

The below management strategy can only be applied to an Eco-Ploughing method and should not be applied to any other area of the pressure main to be constructed. The following assumptions and construction limitations apply to this management strategy option:

Eco-Ploughing will consist of a two stage process:

- **Stage 1**: Soils will firstly be 'ripped' from the natural ground surface with a bull dozer tyne. This method is considered to loosen (by vibration) and displace soil and rocks (if present).
- **Stage 2:** The second pass will insert the pipe (DN450 PE) at the required depth typically between 1.5 and 2m depth.
- No material will be removed from the site during the installation of the pipe.
- No dewatering will be undertaken during the installation of the pipeline.

6.3.1 Stage 1: Initial Ripping of Natural Soil Surface

Prior to 'ripping' the ground surface, a layer of AgLime should be applied to the surface at a rate of 11kg per linear meter of ripped trench (uncorrected liming rate).

AgLime should be placed directly over the area to be ripped, to a maximum of 1m wide.

The rate of AgLime application is based upon the maximum net acidity encountered along this section of the pressure main alignment during the investigations undertaken in June/ July 2013. The liming rate is considered the equivalent of neutralising material required, if material was excavated and stockpiled for neutralisation.

Once AgLime has been applied to the area to be ripped, the bull dozer tyne should then rip the proposed alignment (through the neutralising material) and therefore blend the neutralising material whilst ripping the ground surface. The vibration from the tyne is also considered to assist the blending of the neutralising material to the deeper invert depths.

Photographs of the application of the neutralising material to verify the application volume and successful ripping process should be taken every 250m along the pressure main alignment.

Neutralisation Rate for Bush Forever

The Contractor should inform the WC Environmental Officer prior to commencement of construction and provide the Product Information Sheet (PIS) provided by the AgLime supplier to ensure the liming rate can be corrected prior to application.

The following uncorrected liming rate calculation assumes the following variables and is adopted from the DER ASS Guideline Series (DEC, 2013):

- Maximum Net Acidity - 0.35%S (equivalent 220 mol H+/tonne);
- Safety Factor of 2.0;
- Conservative bulk density[7] of 1.6 t/m^3; and
- Effective Neutralising Value (ENV) of AgLime of 100%

Table 10 provides a summary of the neutralisation rate for the Eco-Plough area.

Table 10 Calculated Neutralisation Rates

ASS Unit	Maximum Net Acidity Result	Assumed Bulk Density [8](tonne/m^3)	Uncorrected Liming Rate (kg/m^2)
Section 2: Ch 1080 to Ch 2600	0.35%S (220 mol H+/tonne)	1.6	11

Note: Uncorrected liming rate has been converted from m^3 into kg per linear meter. The rate will require to be corrected once the ENV value of the imported material is provided

6.3.2 Stage 2: Insertion of Pipe Alignment

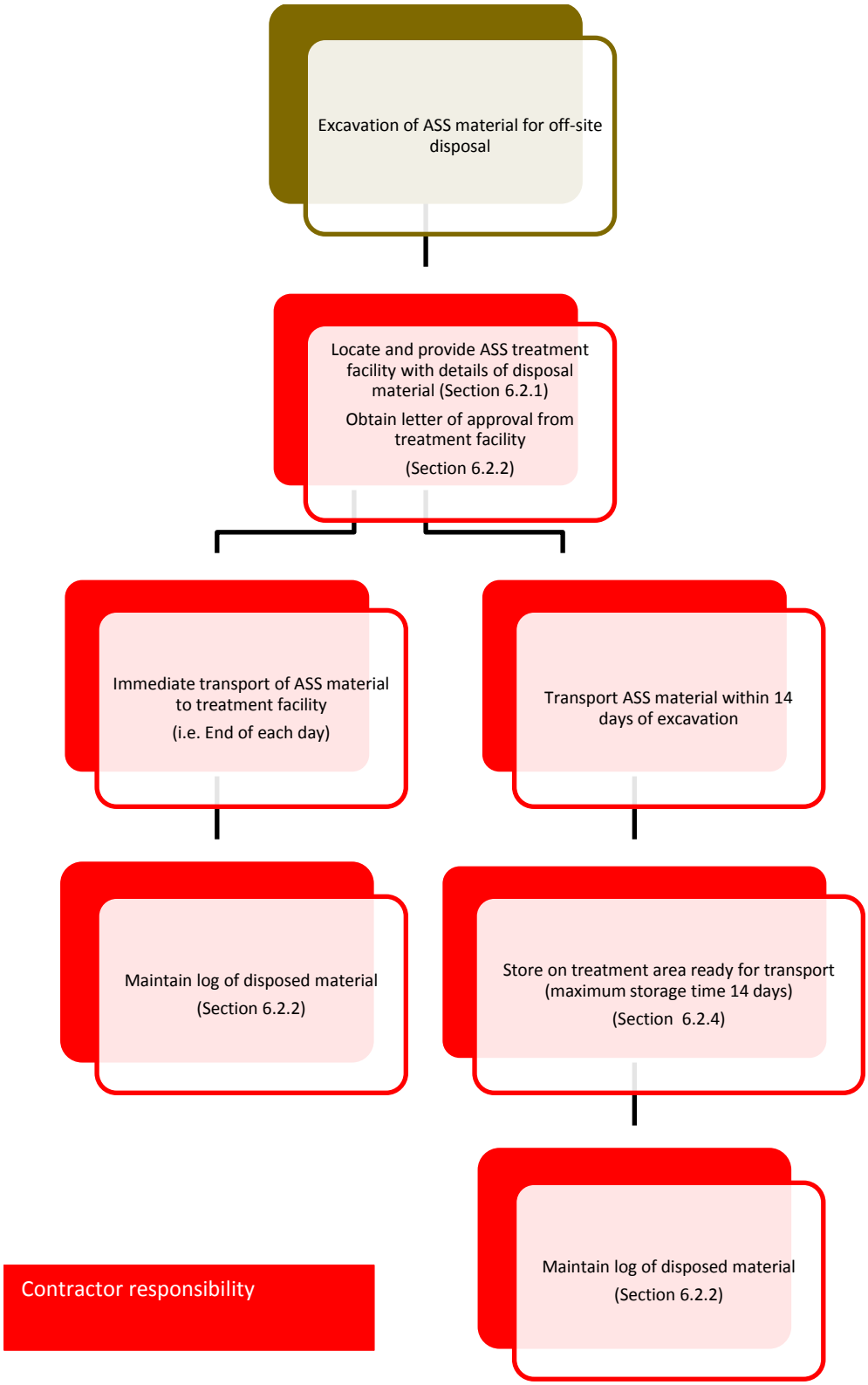
The insertion of the pipeline and backfill of natural material (including neutralising material) within one pass.

No material will be removed from the site during installation.

Photographs will be obtained of the finished alignment at 250m intervals.

[8] Bulk density derived from GHD (2013)

Flow Chart 1 Summary of ASS Off-Site Disposal Procedure



7. Dewatering Management Plan

Baseline groundwater investigations undertaken during August 2013 indicate that groundwater is classified as "Class 1: *Very high alkalinity - Adequate to maintain acceptable pH level in the future"* at most locations along the alignment (BH01, BH03, BH06 North, BH28, BH10, BH11 and BH12). Two (2) locations, BH08 and BH13 were designated as: "*Class 4: Low alkalinity - Inadequate to maintain stable, acceptable pH level"* as per the DER ASS Guideline Series (DEC, 2011).

However it should be noted that this assessment criteria does not take into account the acidity within the groundwater and the geochemistry changes that may take place during potential dewatering within identified PASS zones.

Dewatering operations should aim to maintain the current groundwater quality rather than allowing groundwater to degrade during abstraction operations. On this basis, trigger criteria and actions to manage the groundwater quality should be implemented and monitored on a daily basis during dewatering operations.

7.1 Infrastructure Requiring Dewatering

The geotechnical investigation outlined areas which have been identified as potentially requiring dewatering, determined from the maximum levels observed during the June to July investigations and August 2013 monitoring program. Dewatering is expected to be required where the observed groundwater level is either above the invert or less than 0.25 m below the invert level.

The following locations (Table 11) have been identified as potentially requiring dewatering, determined from the maximum levels observed during the June to July and August observations.

Table 11 Areas of Dewatering (August, 2013)

Section	Chainage	Comments
Section 1	Ch 0 to Ch 200 Ch 450 to 700 Ch 950 to Ch 1080	-
Section 2	-	Eco-Plough area, dewatering not required during installation. Eco-Ploughing to be undertaken when dewatering not required.
Section 3	Ch 2600 to Ch 3300 Ch 3500 to Ch 4316	High total metal concentrations exceeding short term irrigation criteria (filtration required).

Due to the seasonal fluctuation of groundwater, during construction additional areas may be identified where dewatering is required. Scheduling work for drier periods of the year will reduce the requirement for dewatering.

7.2 Dewatering Methods

The dewatering methodology would depend on the finalised construction method employed by the Contractor. However, it is likely that the following dewatering methods, or a combination thereof, could be utilised during construction.

- Dewatering spears - likely to be used for localised areas and/or trenches.
- Sump pumps - for localised dewatering inside pits and/or caissons.

7.3 Dewatering Modelling Calculations and Assumptions

GHD has estimated, using empirical modelling methods, the required abstraction rates and the potential extent of drawdown from dewatering of the excavated trenches for the pressure main. The following groundwater modelling has been based open-cut trench excavation methods with no hydraulic containment based upon the typically shallow depths of dewatering.

7.3.1 Methodology

Estimations of groundwater abstraction and the likely cones of depression have been calculated in accordance with the DER ASS Series Guideline (DEC, 2013).

The radius of influence can be estimated utilising Sichardt's equation:

$$R_o = 3000 \times s \times \sqrt{K}$$

Where:
R_o = radius of influence of an equivalent pumping bore (m)
s = maximum groundwater draw down (m)
K = hydraulic conductivity of aquifer matrix (units of m/s)

Groundwater elevation resulting from dewatering activities is related to the pumping rate, hydraulic conductivity of the aquifer matrix and the radius of influence of pumping by the following equation:

$$H^2 - h^2 = \frac{nq}{\pi k}\left(\ln R_o - \ln r_e\right)$$

Where:
H = saturated thickness of the aquifer undisturbed by pumping (m)
h = saturated thickness of the aquifer at maximum drawdown (m)
k = hydraulic conductivity of aquifer matrix (units of m/s)
R_o = radius of influence of an equivalent pumping bore (m)
r_e = effective radius of an equivalent pumping bore (m)
q = pumping rate of individual dewatering well points (m^3/s)
n = number of well points used to dewater the excavation

The pumping time required for the cone of depression to reach the full extent of water table drawdown is calculated utilising the Cooper-Jacob empirical relationship:

$$R_o = ((2.25\ k\ h\ t)/S)^{0.5}$$

Where:
t = pumping time (seconds)
S = specific yield of aquifer sediments
Other parameters as previously defined

As a minimum, a preliminary assessment of the radial extent of the cone of depression for dewatering operations in ASS areas should be estimated.

7.3.2 Assumptions and Limitations

The scale of dewatering is subject to many assumptions such as trench dimensions (i.e. length, width, depths of excavation) and local hydrogeological conditions (i.e. connectivity to surficial aquifer, proximity of surface water bodies, precipitation).

For the purposes of these estimates, open trenching scenario within a groundwater drawdown of 1m below the groundwater table (August, 2013).

7.3.3 Calculation Assumptions

- Trench width = 3 m

- Trench length = 25 m
- Saturated thickness of the aquifer (H): 31 m
- Saturated thicknesses at maximum drawdown (h): 30 m
- Maximum groundwater drawdown: 1.0 m
- Dewatering depth: +0.5 m below trench invert
- Default hydraulic conductivities of the aquifer matrix (k): 1.91x10-4 to 9.49x10-5 m/sec (16.5 to 8.2 m/day) (Davidson, 1995)
- Specific yield of superficial aquifer (S): 0.1 (Davidson, 1995)

The above modelling assumptions have been utilised to provide the results outlined in Table 12.

Table 12 Estimated Abstraction Rate and Radius of Drawdown Estimation

Predominant Lithology	Hydraulic conductivity (m/s)*	Drawdown (m)	Cone of Depression (R_0) (m)	Estimated Abstraction Rate (L/s)	Time taken to establish required drawdown (hours)
Medium grain SAND	1.91 x10-4	1.5	41	17	4
Fine to medium grain SAND	9.49 x10-^{5}	1.5	29	10	4

Initial abstraction rates may be high to cause mass groundwater drawdown and reduce the necessary pumping time to achieve the desired dewatering invert level however GHD expect maintenance abstraction rates to be in the vicinity of 12 L/s for the project.

These abstraction rate and volume estimates are approximations only and will vary according to (but are not limited) the following:

- groundwater levels (subject to seasonal variations from rainfall events, abstraction by local residents, mounding caused by onsite re-infiltration);
- changes in ground conditions which affect the hydraulic conductivity of the soil profile;
- any construction schedule changes; and
- any sewer invert level changes.

7.4 Groundwater Acidification Risk Matrix

GHD classified the potential groundwater acidification risk at the well locations using groundwater laboratory data. Parameters assessed include acidity, alkalinity, pH, ORP, sulfate, total aluminium and iron concentrations. The likelihood of dewatering being required within 50 m was also taken into consideration.

A summary of this matrix is presented in Table 13 to characterise the risk of groundwater acidification and determine the likelihood of the groundwater (dewatering effluent once abstracted) requiring lime dosing to adjust the pH of the effluent.

Table 13 Groundwater Acidification Risk Matrix

Well ID	Chainage	Groundwater Acidification Risk	Likelihood groundwater treatment
BH01	47	Low	Possible
BH03	570	High	Highly Likely
BH05 North	Unable to be sampled		
BH05 South	Unable to be sampled		
BH06 North	2,667	Moderate	Likely
BH06 South	2,674	Moderate	Likely
BH08	3,161	High	Highly Likely
BH10	3,665	Moderate	Likely
BH11	3,853	Low	Possible
BH12	4,199	Moderate	Likely
BH13	4,395	High	High Likely
BH16	Unable to be sampled		
BH19	Unable to be sampled		
BH22	Unable to be sampled		
BH25	Unable to be sampled		
BH28	3,553	Moderate	Likely

7.5 Management of Dewatering Effluent

Monitoring of the dewatering effluent and groundwater will be undertaken in accordance with Table 17 and the trigger levels provided within this table are based upon the DER ASS Guideline Series (DEC, 2011) and the baseline water quality parameters obtained during August 2013.

7.5.1 Dewatering Effluent Management

Dewatering effluent should be directed to a retention basin or holding tank immediately after abstraction. The retention basin will be constructed as per the following requirements to enable monitoring of the effluent and flocculation of metals prior to discharge.

- Dewatering effluent will be initially directed to an impermeable retention basin or holding tank (similar to a sea container), to allow sufficient time for the mixing (if applicable) and aeration process to flocculate and settle solids, subject to space constraints.

The retention area will be of sufficient size to contain the dewatering effluent and allow the filtration of metals and Total Suspended Solids (TSS) prior to discharge.

Table 14 outlines the recommended dimensions of the retention area and is based on an abstraction rate (and ultimately the construction method) proposed by the Contractor.

It is important to note that prior to the basin size being set by the Contractor the assumptions behind the dewatering volume calculated in this report will require validating (i.e. dewatering section dimensions, groundwater depth, dewatering rate, etc.).

The Contractor is responsible for the construction and modification (if required) of the retention area.

A schematic of the dewatering effluent management system considered suitable for the site is presented in Appendix D. Variations of the effluent management system must be discussed with the WC Environmental Officer prior to commencement.

Table 14 Recommended Retention Basin Sizes (based on depth of 0.5m)

Discharge Rate (L/S)*	Approx. Area (m^2)	Approx. Length (m)	Approx. Width (m)
1.60	12.25	4.95	2.48
3.00	24.51	7.00	3.50
6.00	49.01	9.90	4.95
12.00	98.03	14.00	7.00
18.00	147.04	17.15	8.57

Table 14, adapted from Table 3.1 of DoE, 2004)

* Assuming one hour of effluent storage capacity.

7.5.2 Dewatering Effluent Disposal Options

The dewatering disposal options will depend on the dewatering rate, infiltration rates and the abstracted groundwater quality.

The currently identified disposal options and in order of preference, are:

- Re-infiltration within close proximity to the dewatering operations (i.e completed service trenches) identified on Figure 6;
- Discharge into sewer network (permit required); and
- Discharge into stormwater system (permit required).

Re-infiltration

Re-infiltration is the preferred method of disposing of effluent subject to water quality and the trigger criteria outlined in Table 17.

Re-infiltration on-site may be a feasible dewatering discharge disposal option, if a suitable area is available during construction. Re-infiltration (post retention) may be viable over completed service trenches, however the re-infiltration rate would depend on the dewatering rates/volume and the infiltration capacity and depth to groundwater level at the time of construction.

Abstraction in some areas may exceed infiltration rate and the infiltration of effluent over completed services may not be a sole viable option. In this instance excess dewatering effluent can either be stored in holding tanks for infiltration over a period of time during the construction period or the construction of infiltration basin located to the east of Ch 0 to 1080 (subject to permission from the land owner). The construction of basins or disturbance of any Bush Forever area is not permitted.

Discharge to Sewer

Disposal to the sewer may be a feasible option, however, the following should be considered:

- Approval would be required from the Water Corporation by lodging a “one-off discharge of industrial waste”.
- The disposal volume is normally restricted by the sewer capacity, which would need to be discussed with the Water Corporation and would depend on the expected discharge rates and volumes.

This disposal option would require limited on-site treatment (pH adjustment and Total Suspended Solids (TSS) given the groundwater quality information obtained in August 2013.

Discharge to sewer may also be considered as a contingency measure as a backup to other selected disposal option(s) such as re-infiltration.

7.5.3 Treatment of Dewatering Effluent

Baseline groundwater data obtained during August 2013 provides an indication of the quality of the effluent likely to be abstracted during dewatering, however water quality can change during the dewatering process (as groundwater is drawn down in from within the cone of depression, subjected to increased aeration/oxygen).

Neutralisation via a Lime Dosing Unit (LDU) prior to discharge is likely to be required during construction and dewatering. As such a LDU should be sort and all effluent should pass through the LDU and neutralised on an 'as required' basis.'

7.5.4 Filtration of Dewatering Effluent

Baseline groundwater quality indicates the dewatering effluent is likely to have a dissolved metal concentration (particularly iron and aluminium) below the STI and DER ASS Criteria (10mg/L (STI) and 1mg/L DER ASS Criteria respectively) indicating that filtration of dewatered effluent is not required during the dewatering operations.

Groundwater quality information indicates exceedances when compared to Freshwater Guidelines, these are considered conservative criteria, however effluent should not be discharged directly to surface water bodies without retention and/or consultation with the WC Environmental Officer.

A schematic of the recommended dewatering effluent treatment system is presented as Appendix D.

7.6 Dewatering Effluent Monitoring

7.6.1 Dewatering Effluent Monitoring Locations

Dewatering effluent will be monitored at the following locations throughout the dewatering program and analysed for the parameters outline in Table 15.

- **Monitor Point 1**: Monitoring effluent prior to entering the retention basin (before LDU if this is required).
- **Monitor Point 2**: Monitoring effluent prior to entering the infiltration area.

7.6.2 Dewatering Effluent Monitoring Suite

Dewatering effluent should be tested for the parameters and analytes outlined in Table 15.

Table 15 Dewatering Effluent Monitoring Suite

Dewatering Effluent Monitoring (DEC 2013)	
Total acidity	Manganese (total)
Total alkalinity	Nickel (total)
pH	Zinc (total)
Sulfate	Selenium (total)
Chloride	Ammoniacal nitrogen
Aluminium (dissolved)	Hydrogen sulfide
Aluminium (total)	EC
Arsenic (total)	Total suspended solids (TSS)
Chromium (total)	TDS
Cadmium (total)	Total nitrogen
Iron (total)	Total phosphorus
Iron (dissolved)	Filterable reactive phosphorus (FRP)

7.6.3 Groundwater Monitoring during Dewatering Operations

Groundwater will be monitored every second day by the Contractor during dewatering from the monitoring bores outlined in Table 13 and identified on Figure 6 when the bores are located within 200m of the dewatering operations for the field parameters:

- pH, EC, total acidity and static water level.

Groundwater results to be provided on a weekly basis to the WC Environmental Officer or within 24 hours, if groundwater quality degrades to the trigger criteria outlined in Table 16.

Table 16 Groundwater Trigger Criteria

Analyte	Trigger Criteria	Determined From	Action
pH	- 10% from baseline pH value	Second day field results	Notify WC Environmental Officer within 24hrs
Total Acidity	>25% increase from the baseline value	Second day field results	
Static Groundwater Level	- 10cm from baseline values at maximum 100m radius of dewatering operations.	Second day field results	

Table 17 Dewatering Effluent Monitoring Matrix: Monitoring Frequency, Analytes, Trigger Levels and Actions

	Trigger	Action	Monitoring
1a.	**Total titratable acidity <40mg/L** pH >6	Continue daily field measurements of pH and total titratable acidity	**Daily** – field measurement: pH, electrical conductivity (EC) & Total Titratable Acidity (TTA). **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH
2a.	**Total titratable acidity <40mg/L** pH in range of 4 to 6.	Undertake neutralisation treatment (liming)	**Daily** – field measurement: pH, EC & TTA, total alkalinity **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH
3a.	**Total titratable acidity in range 40mg/L to 100mg/L** pH>6	Undertake neutralisation treatment (liming) Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals	**Daily** – field measurement: pH, EC & TTA, total alkalinity **Weekly** - laboratory analysis: total acidity, total alkalinity, pH **Fortnightly** - field measurement: dissolved oxygen (DO), redox potential (Eh)
4a.	**Total titratable acidity in range 40mg/L to 100 mg/L** pH in range of 4 to 6	Undertake neutralisation treatment (liming) Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals	**Daily** – field measurement: pH, EC, TTA, total alkalinity **Weekly -** laboratory analysis: total acidity, total alkalinity, pH **Fortnightly** - laboratory analysis: total acidity, total alkalinity, pH, sulfate, chloride, total iron, dissolved iron (filtered), total aluminium, dissolved aluminium (filtered), total arsenic, total chromium, total cadmium, total manganese, total nickel, total zinc, total selenium, ammoniacal nitrogen, EC, total suspended solids (TSS), total dissolved solids (TDS), total nitrogen (TN) and total phosphorus (TP) **Fortnightly** - field measurement: DO, Eh
5a.	**Total titratable acidity >100mg/L** or pH<4 or **Total alkalinity <30mg/L**	Increase neutralisation treatment (liming) rate Effluent should be aerated to precipitate dissolved iron and directed to a series of settlement basins/trenches or other treatment system to allow removal of iron and other metals Advise Department of Environment Regulation (DER) Contaminated Sites Branch (CSB) immediately. CSB may advise appropriate action which may include ceasing dewatering	**Twice Daily –** field measurement: pH, EC, TTA, total alkalinity **Weekly** - laboratory analysis: total acidity, total alkalinity, pH, sulfate, chloride, total iron, dissolved iron (filtered), total aluminium, dissolved aluminium (filtered), total arsenic, total chromium, total cadmium, total manganese, total nickel, total zinc, total selenium, ammoniacal nitrogen, EC, TSS, TDS, TN and TP. **Fortnightly -** field measurement: DO, Eh May be required to undertake investigations to determine the size of the “acidic footprint” created and manage this impact appropriately

Additional notes:

[1] A slurry made from crushed limestone is the generally preferred neutralisation material. Other neutralising agents, such as hydrated lime or quick lime can be used, however they quickly increase the receiving waters' pH and can result in pH overshoot.

[2] Measurement of metal concentrations in dewatering effluent should be as total concentrations from an unfiltered water sample. These concentrations should then be used to determine appropriate treatment options for the effluent and to identify any emerging trends in groundwater quality. It is not the intention that these values for total metals be directly compared against environmental or health-based criteria for dissolved metals. However, when determining treatment options, it should be borne in mind that: **a)** any metals contained within suspended solids have the potential to be mobilised if pH and/or REDOX conditions change (which is obviously fairly common in ASS environments); and b) if dewatering effluent is to be discharged into a receiving environment then these suspended solids will be discharged along with the water.

Adapted from (DEC 2011).

Table 18 Roles and Responsibilities – Dewatering Effluent and Groundwater Monitoring

Responsibility	Task	Actions
Contractor	Continuously monitoring the dewatering discharge rate and volume. Daily monitoring and recording of the pH, EC, TTA and TAAlk of the dewatering effluent, subject to trigger criteria outlined in Table 17. When using retention areas, water sampled daily from the inlet and outlet point supplying the first tank. The trigger criteria specified in Table 17 will be used to determine the level of treatment required, or if more frequent field monitoring is required. Daily monitoring of dewatering effluent with respect to visual assessment, for example high sediment loading, iron precipitation, colour, odour etc. Daily assessment of the geofabric textiles (when installed) within the dewatering treatment system and cleaning/replacement, as required. Second day monitoring of the groundwater bores at the site for pH, EC, TTA during dewatering operations. Fortnightly groundwater monitoring of groundwater bores during dewatering operations as per Section 7.6.3.	Results of the water monitoring programs along with actions taken to achieve water quality targets including quality of the dewatering effluent to be provided to the WC Environmental Officer on a weekly basis. Results to be provided within 24 hours of water quality falling outside the parameters in Table 17.

7.7 Dewatering Management Roles and Responsibility

The water monitoring program including roles and responsibilities, outlined in Table 18, will be undertaken during dewatering operations.

A flow chart outlining the Actions and Responsibilities in relation to dewatering effluent and is included as Flow Chart 2. It is anticipated that this flow chart will be distributed amongst the Contractors at the start of the construction phase to compliment and disseminate the information contained within this management plan.

Example checklists for groundwater and dewatering effluent monitoring for the Contractor are included in Appendix E. The daily field sheet outlines all daily field measurements that are required to be recorded by the appointed Contractor and submitted to the Water Corporation on a weekly basis.

7.8 Decommissioning of Retention Basin

At the completion of the works, the WC Environmental Officer (or Principal's Environmental Consultant on formal delegation from the WC Environmental Officer) will be responsible for collection of samples of the accumulated sediments at the base of the retention basin (if utilised instead of the holding tank). The results will be used to determine the appropriate decommissioning requirements and disposal method for the accumulated sediments.

Accumulated sediments at the base of the holding tank should be disposed of by the Contractor to an appropriate facility. Sediments should not be disposed of on-site without prior consultation with the WC Environmental Officer.

Sample analyses will include, but not be limited to:

- SPOCAS; and
- Metals (Al, As, Cr, Cu, Fe, Mn, Pb, Ni, Se and Zn).

Once laboratory analysis is completed, sediments will be classified based upon the *Landfill Waste Classification and Waste Definitions* (DoE, 1996, as amended December 2009) and disposed offsite at an appropriate waste disposal facility.

7.9 Residential Bores Affected by Dewatering Operations

A search of the Department of Water (DoW) borehole database (WIN) was carried out to identify any registered bores within close proximity of the Site in March 2014.

Two (2) registered bores are located within a 500m radius of the site, both of these bores are located >100m from any dewatering operations and are operated by the City of Kwinana. The bores are licensed to abstract water from the superficial aquifer, the aquifer intended to be dewatered during construction.

Additionally some properties within and adjoining the works may have bores for producing water for their gardens. As the functionality of these bores and the quality of water may be affected by the dewatering works required for the construction of the infrastructure property owners/occupiers will have to be notified of the works prior to commencement.

The dewatering operations are not anticipated to extend beyond 100m of the dewatering site and therefore bores on the WIN database should remain unaffected.

7.9.1 Inspections of Bore and Reticulation Systems

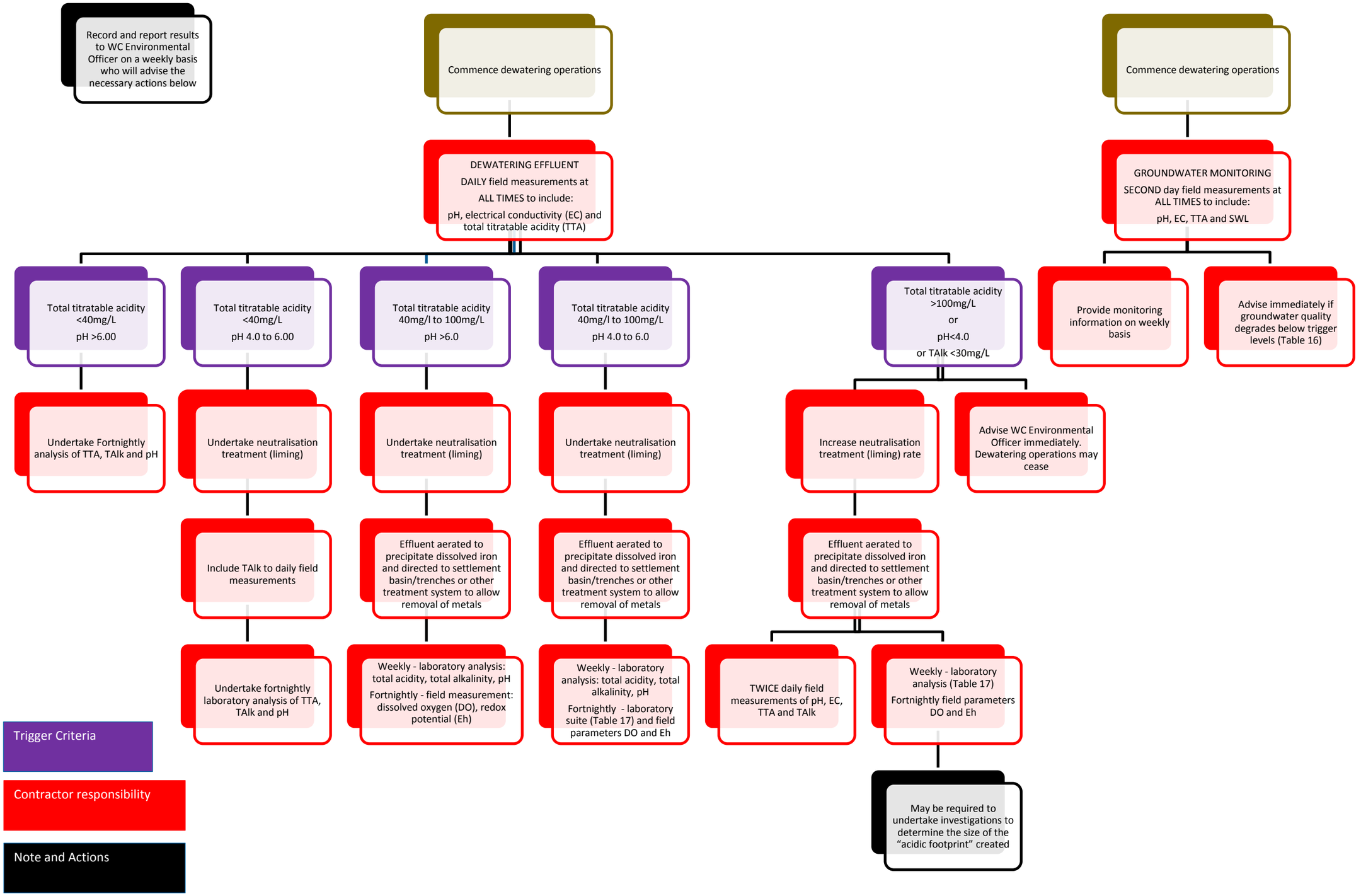
When dewatering is to commence at the pump station site, the Contractor shall:

- Request a list from the Superintendent identifying the owners and occupiers of known bores within 100m radius of the dewatering operations.
- Request an inspection of all properties within a 100m radius of the pump station to determine, if there is a bore on the property;
- Obtain the owner/occupiers permission and test the bore to confirm whether the bore is in operational or not;
- If the bore is operational then confirm which of the sprinkler or other outlets are in working order;
- Obtain the owner/occupiers signature on a 'pro forma' letter and plan of the sprinkler system to confirm they agree with results of the inspection;
- Leave the original signed letter and plan with owner/occupier, and retain a copy for the Contractor records;
- Leave a letter with the owner/occupier advising them of the start and finish date of dewatering work that will affect their property and advising them that they should not use the bore until advised by the Contractor;
- Reinspect each property with a working bore following completion of dewatering work and confirm that what equipment was working satisfactorily before, is still working satisfactorily;
- Obtain the owner/occupiers signature on the 'pro forma' letter and plan of the sprinkler system to confirm they are satisfied with results of the final inspection.

7.9.2 Records of Bore and Reticulation System Inspections

The Contractor shall maintain a file of copies of the 'bore and reticulation system' letters endorsed by the owner/occupier. A copy of the letters shall be provided to the Superintendent at the kick-off meeting.

Flow Chart 2 Summary of Monitoring and Management during Dewatering Operations



8. Groundwater Monitoring Program

8.1 General

Groundwater monitoring is an integral part of any project, where dewatering is undertaken as it allows for any changes in land and water quality to be monitored pre, during and post construction, giving an indication as to the success of the management strategies implemented.

A comprehensive monitoring program (including additional bores) will require to be finalised once the design and construction methods have been finalised. The extent of dewatering operations and type of construction method will dictate the number and location of bores required.

8.1.1 Additional Groundwater Wells

GHD recommend prior to construction commencing that wells at locations BH05 North and BH05 South be re-drilled to monitor groundwater levels and chemistry. This will provide a better network of groundwater wells to monitor pre, during and post-construction.

8.1.2 Replacement of Un-operational Groundwater Wells

It is considered that if any groundwater wells are rendered unusable as a result of construction, they will be required to be replaced as soon as possible after the well has been determined to be unusable. The WC Environmental Officer is to be informed immediately when a well has been damaged or rendered unusable.

8.2 Groundwater Monitoring Program

The groundwater monitoring program will utilise selected monitoring wells listed in Table 19 and shown in Figure 6 for the duration of the site works.

Table 19 Groundwater Monitoring Wells

BH ID	Chainage	Co-ordinates		Elevation (m AHD)	Depth (m)
		Easting	Northing		
BH01	47	398909	6445341	26.80	3.45
BH03	570	399047	6444936	27.00	3.45
BH06 North	2,667	400565	6443495	22.00	6.00
BH06 South	2,674	400563	6443483	22.50	6.45
BH08	3,161	400922	6443153	24.25	2.80
BH10	3,665	401281	6442799	23.40	4.50
BH11	3,853	401414	6442667	23.50	4.50
BH12	4,199	401666	6442408	23.75	4.50
BH13	4,395	401821	6442405	24.75	4.50
BH16	1,396	399664	6444386	24.40	6.00
BH19	1,685	399869	6444183	23.90	6.00
BH22	2,000	400097	6443966	23.80	6.00
BH25	2,293	400303	6443757	22.75	6.00
BH28	3,553	401204	6442881	23.25	3.00

Note: The proposed additional bores are likely to be required to monitor groundwater quality during dewatering operations. The location and extent of the monitoring program may be modified once the construction method is finalised.

8.2.1 Groundwater Monitoring Pre-Construction

The groundwater results presented in Section 5 are considered to be baseline groundwater geochemistry at the time of reporting. It should be noted that groundwater geochemistry within the well sampled is likely to change between the time this report is prepared and the commencement of construction.

Groundwater monitoring will be undertaken of the existing groundwater wells (Table 17) and any additional re-installed monitoring wells considered appropriate for the construction program within four (4) weeks prior to construction and this will be considered the most representative baseline groundwater quality against which results collected during and post-construction will be assessed.

8.2.2 Groundwater Monitoring During Construction

Groundwater monitoring will be undertaken on a fortnightly basis (during dewatering only) in order to assess groundwater quality trends within monitoring bores located within 200m radius of the dewatering operations. Table 20 outlines a summary of the overall monitoring program.

8.2.3 Groundwater Monitoring Post-Construction

Three (3) groundwater monitoring events undertaken bi-monthly over six months will be undertaken once construction has been finalised, if dewatering extends beyond 4 weeks and/or deterioration of groundwater quality is noted. All bores monitored during dewatering operations will be included in the post construction monitoring program.

Table 20 Overall Groundwater Monitoring Program

Parameter	Frequency	Responsibility
Pre-Construction		
Groundwater Suite as outlined in Section 5.2.	Prior to site works commencing	Principal's Environmental Consultant
During Construction (Dewatering Periods Only)		
Groundwater Suite as outlined in Section 5.2.	Fortnightly during dewatering (unless dewatering quality deteriorates – refer to Trigger criteria outlined in Table 17	Contractor
Post-Construction		
Groundwater Suite as outlined in Section 5.2.	Post-Construction once construction and dewatering have ceased	Principal's Environmental Consultant

8.3 Groundwater Action Criteria

GHD recommends the following groundwater trigger criteria (Table 21) are implemented during monitoring events and during dewatering to assess groundwater quality trends and ensure groundwater quality is not degraded.

Table 21 Groundwater Trigger Criteria

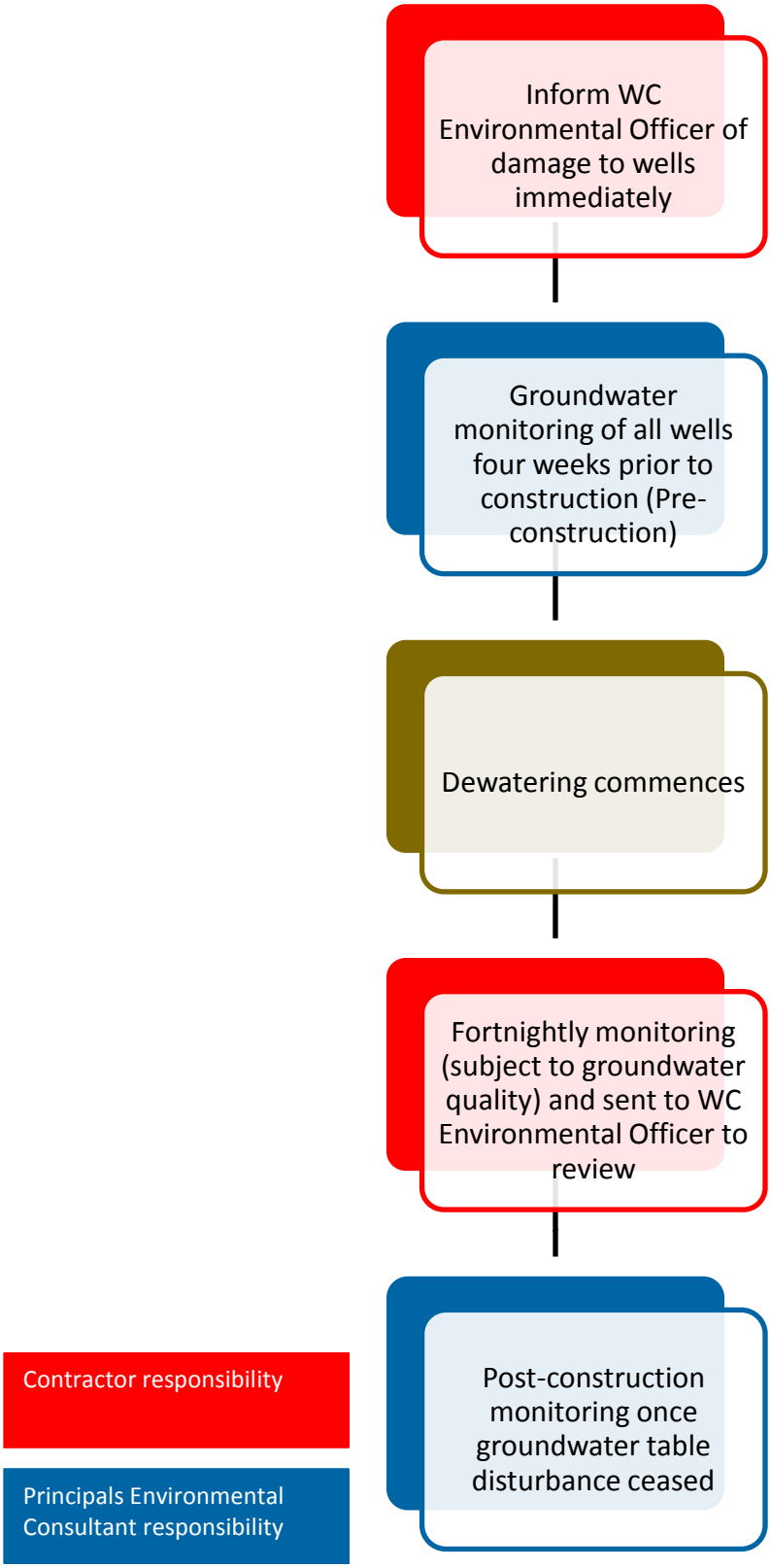
Analyte	Trigger Criteria	Responsibility	Determined From
pH	- 10% baseline value	WC Environmental Officer	Daily field results AND Fortnightly laboratory results
Total Acidity	>25% increase from the baseline value	WC Environmental Officer	Daily field results AND Fortnightly laboratory results
Soluble Aluminium	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results
Soluble Iron	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results

The pH and acidity will be compared to background results obtained from monitoring well baseline monitoring and the trigger values given in Table 21 (frequency of monitoring should be altered accordingly by the WC Environmental Officer).

The Flow Chart 3 provides a summary of the groundwater monitoring program and responsible parties for the monitoring.

Contingency measures outlined within Section 9 should be adhered to if the groundwater trigger criteria are exceeded.

Flow Chart 3 Summary of Groundwater Monitoring



9. Contingency Strategy

GHD recommends the following dewatering effluent and groundwater trigger criteria (Table 22) are implemented during monitoring of effluent:

Table 22 Dewatering Effluent Trigger Criteria

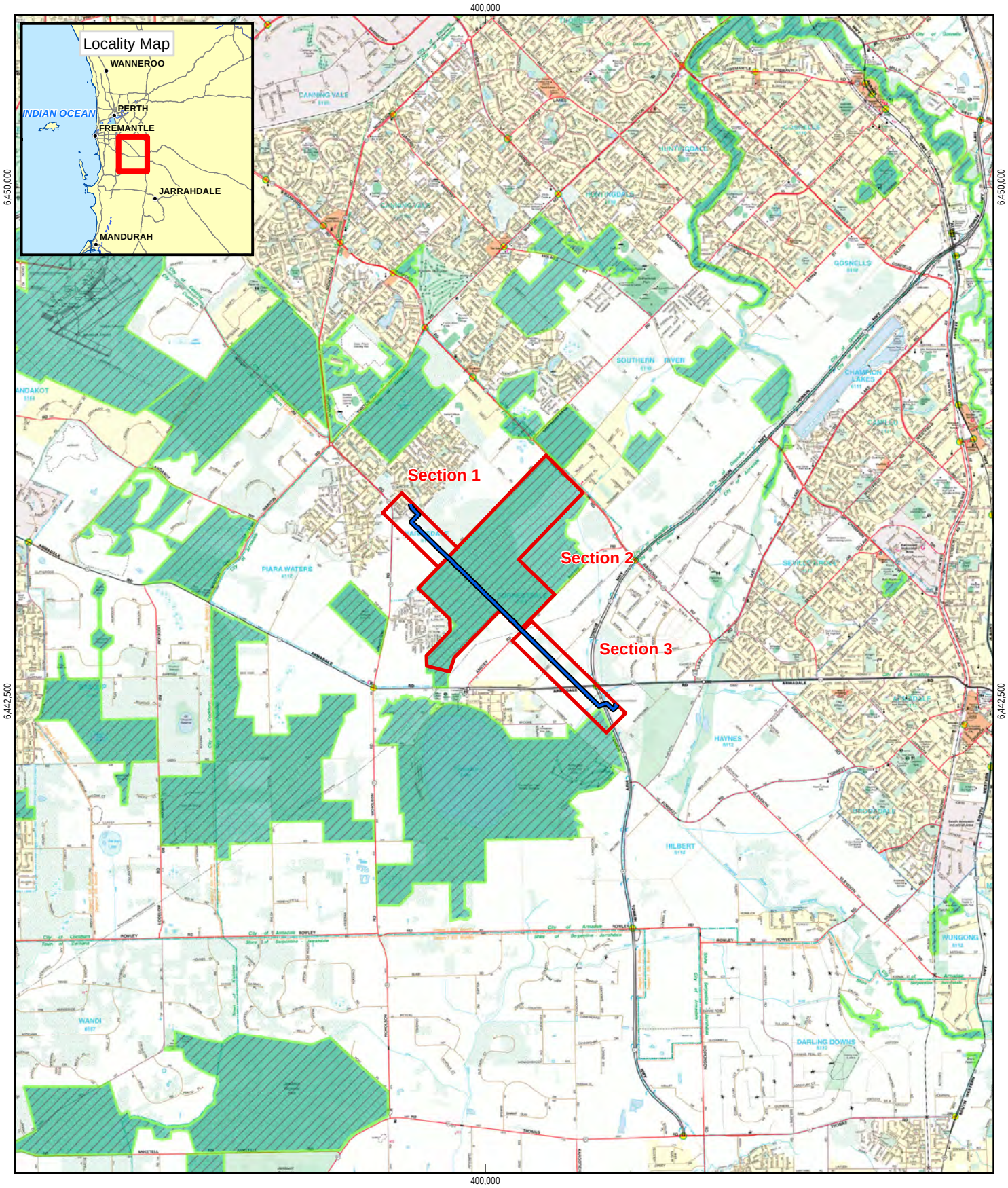
Analyte	Trigger Criteria	Responsibility	Determined From
pH	- 10% baseline value	Contractor	Daily field results AND Fortnightly laboratory results
Total Acidity	>25% increase from the baseline value	Contractor	Daily field results AND Fortnightly laboratory results
Soluble Aluminium	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results
Soluble Iron	>1 mg/L (or >25% increase from the baseline value)	WC Environmental Officer	Fortnightly laboratory results

If any of the triggers in are exceeded, it is recommended that the dewatering operations are ceased (where practically possible) to avoid unnecessary environmental damage. If there is a significant delay between a trigger level being reached and the mitigation measures being implemented, this could result in unacceptable damage to groundwater quality and other sensitive receptors. The WC Environmental Officer may advise on the following contingency measures to take place:

- Commence/increase liming rates via the automated lime dosing unit;
- Employ the use of aeration/settlement tanks with geotextile fabric to remove total iron, aluminium and other metal floc;
- Implementation of longer settlement times (which may involve more settlement tanks to cater for areas requiring significant discharges);
- Implementation of increased aeration (for example, use of sprayer head);
- Modification of dewater effluent reinjection to limit drawdown in area of concern;
- Modification of the construction method (i.e. implementation of cut off walls to localise impact of dewatering and reduce the cone of depression).
- The WC Environmental Officer should be consulted if pH and total acidity trigger criteria in Table 16 are exceeded during dewatering.

Appendices

Appendix A - Figures



Legend

- Pressure Main
- Section
- Bush Forever

1: 75,000 (at A4)

0 375 750 1,500 2,250 3,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

Water Corporation
Keane Road Pressure Main
Draft Acid Sulfate Soil and Dewatering Management Plan

Job Number 61-29471
Revision 0
Date 17 Apr 2014

Locality Plan and Site Location

Figure 1

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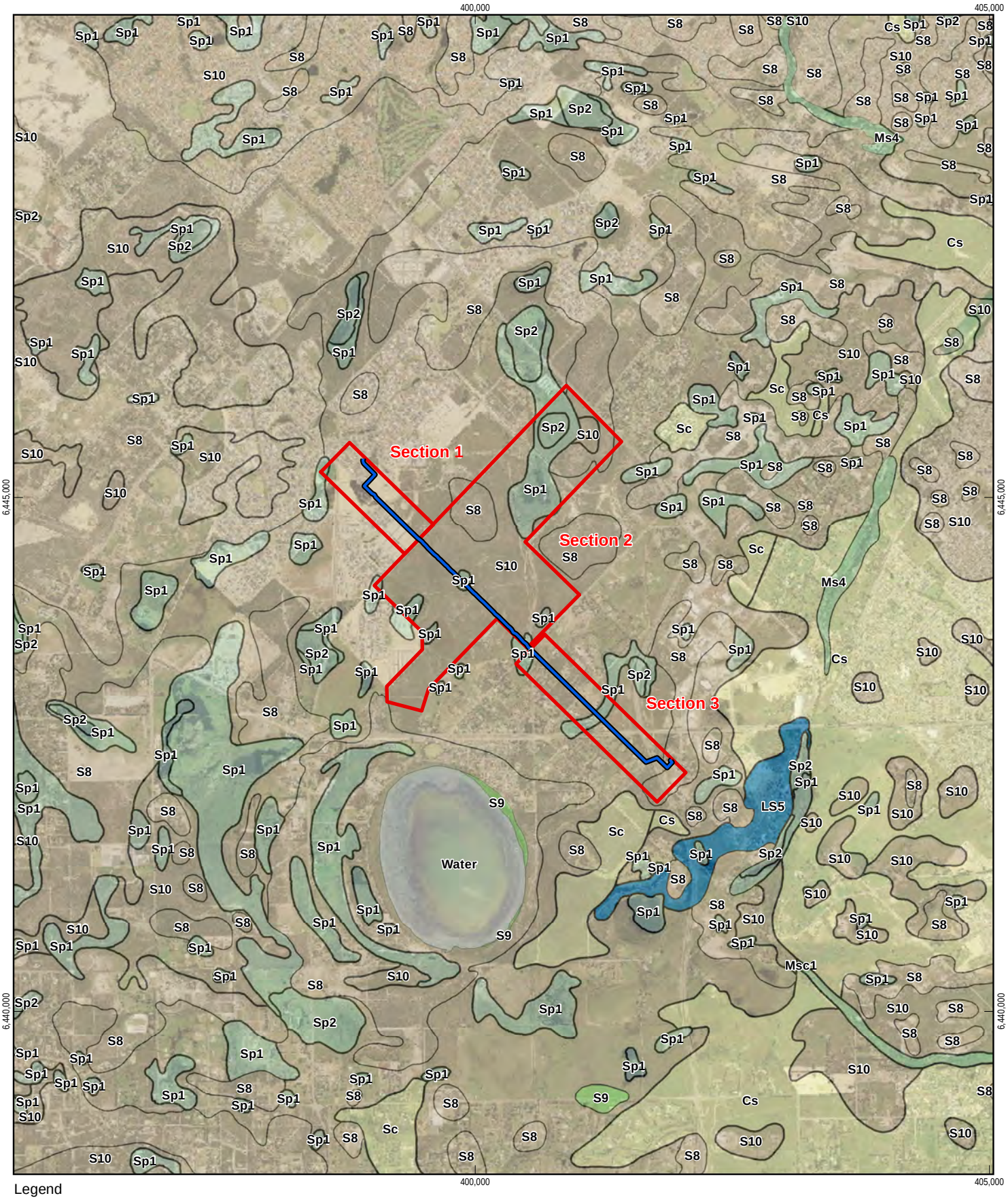
Data source: GHD: Pressure Main - 20140415, Section - 20140415; DoP: Bush Forever - 20120301; GA: Topo 250k Series 3 - 2006; WC: Streetsmart Directory - 2011. Created by: mczekaj



Legend

- Pressure Main
- Section

Geology 50k

- Sp1 - PEATY SAND - grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin
- Sp2 - PEAT-RICH SAND - fine to medium-grained quartz sand with much brown to black organic material, grades to peat, of lacustrine origin
- Ms4 - SANDY SILY - cream to pale brown alluvium, clayey in part, fine to medium-grained sand, of alluvial origin
- Msc1 - CLAYEY SANDY SILT - pale brown, angular to rounded sand, low cohesion, of alluvial origin
- S9 -
- LS5 - LIMESTONE - white to cream, fine-grained, algal lamination common
- S8 - SAND - white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangul0ar to subrounded, minor heavy minerals, of eolian origin
- S10 - SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin
- Sc -
- Cs -
- Water -

1: 50,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Keane Road Pressure Main
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Published Geological Information

Figure 2

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Revision	0
Date	17 Apr 2014

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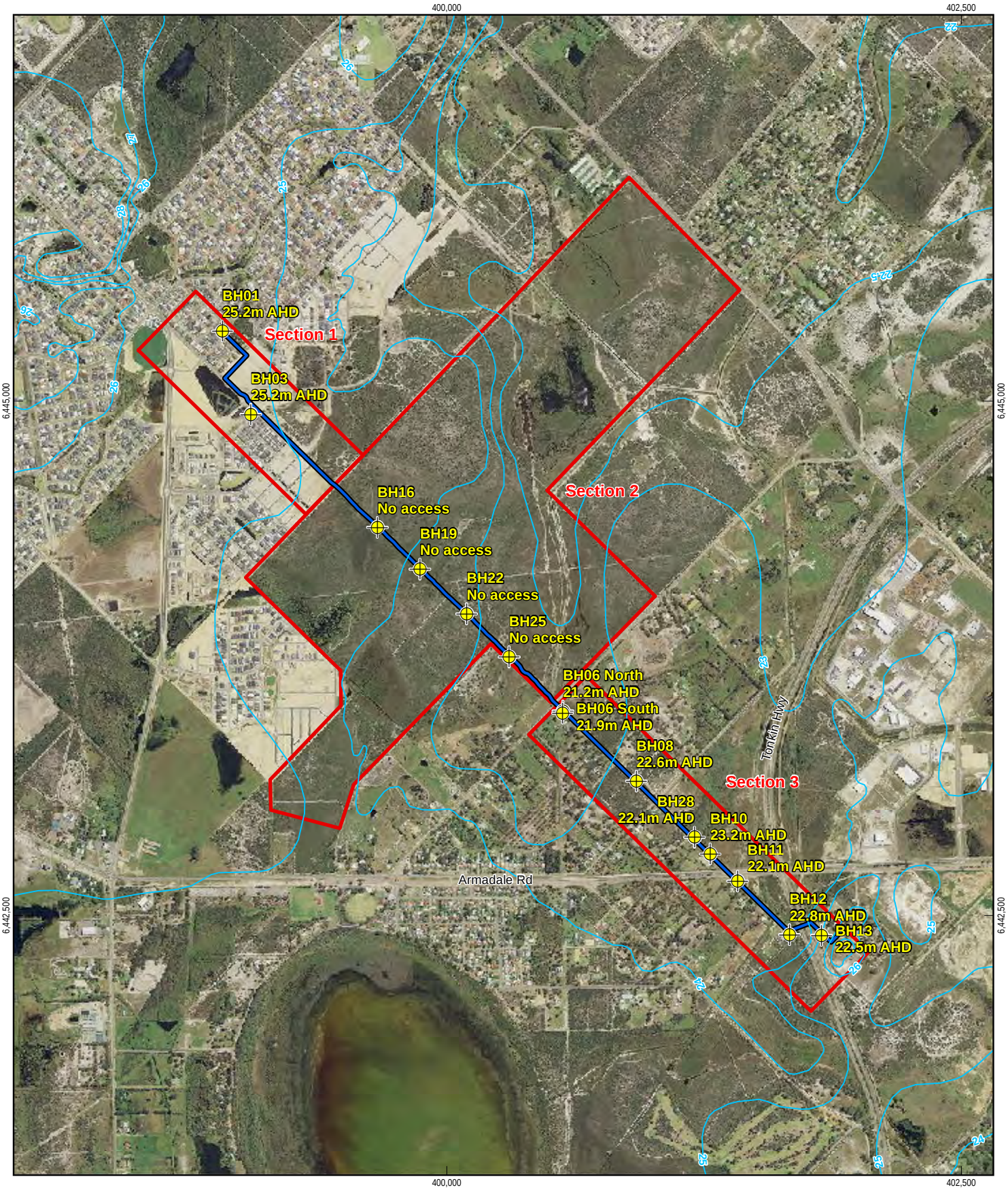
Data source: GHD: Pressure Main - 20140415, Section - 20140415; Landgate: Virtual Mosaic - 20140416; DMP: Geology 50k - 20120612. Created by: mczekaj



Legend

- Groundwater Well
- Groundwater Contours Maximum
- Pressure Main
- Section

1: 25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Keane Road Pressure Main
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Maximum Groundwater Contours (Perth Groundwater Atlas) and August 2013 Groundwater Levels

Job Number	61-29471
Revision	0
Date	17 Apr 2014

Figure 3

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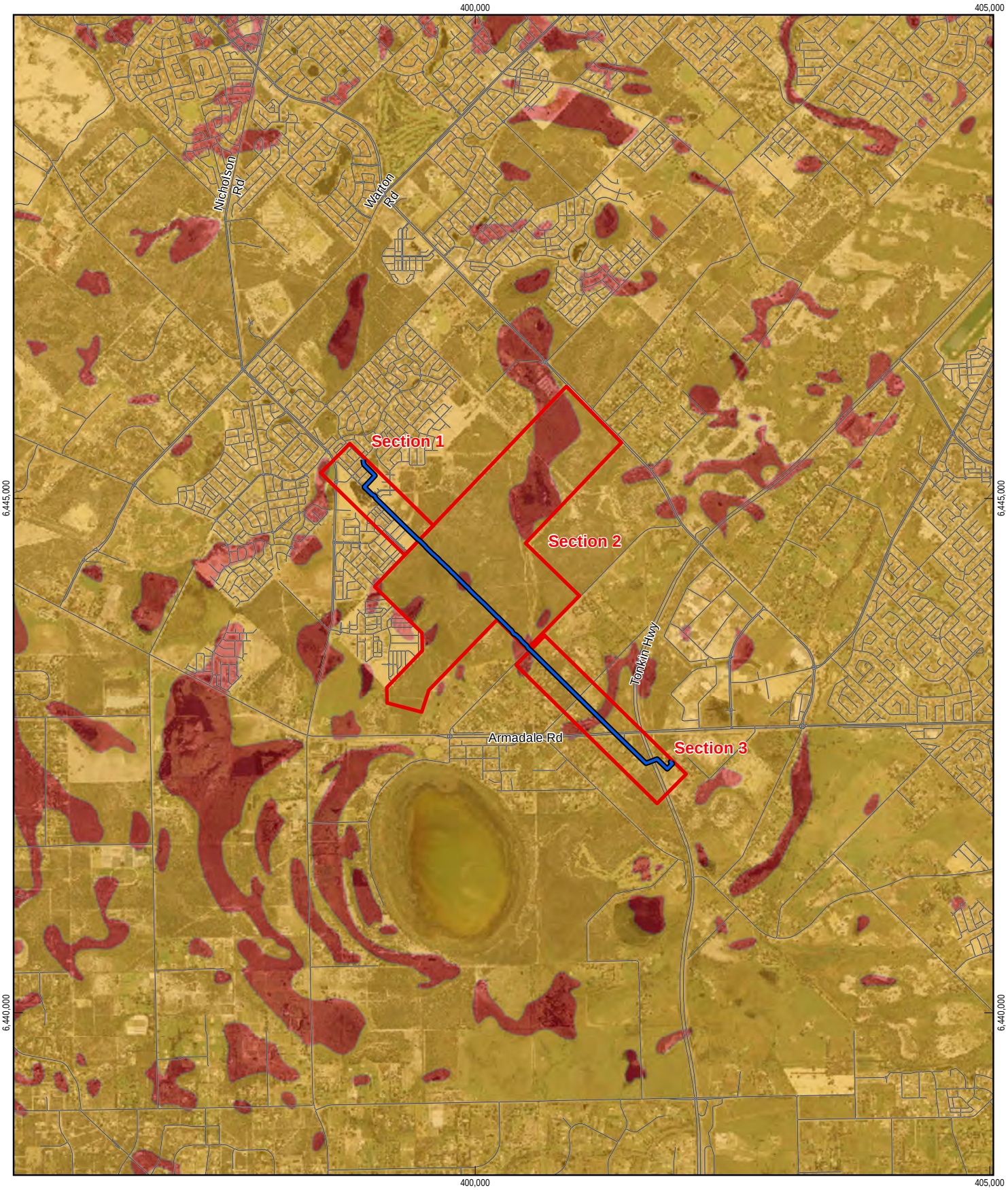
Data source: GHD: Pressure Main - 20140415, Section - 20140415, Groundwater Well - 20140416; DoW: Groundwater Contours Maximum - 20050725; Landgate: Virtual Mosaic - 20140416, Road Names - 20140416. Created by: mczekaj



Legend

- Pressure Main
- Section
- Road

Acid Sulfate Soil Risk

- Class 1 - High to moderate risk of ASS occurring within 3m of natural soil surface
- Class 2 - Moderate to low risk of ASS occuring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

1: 50,000 (at A4)

0 250 500 1,000 1,500 2,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

N

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Keane Road Pressure Main
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Date 17 Apr 2014

Acid Sulfate Soil Risk Mapping

Figure 4

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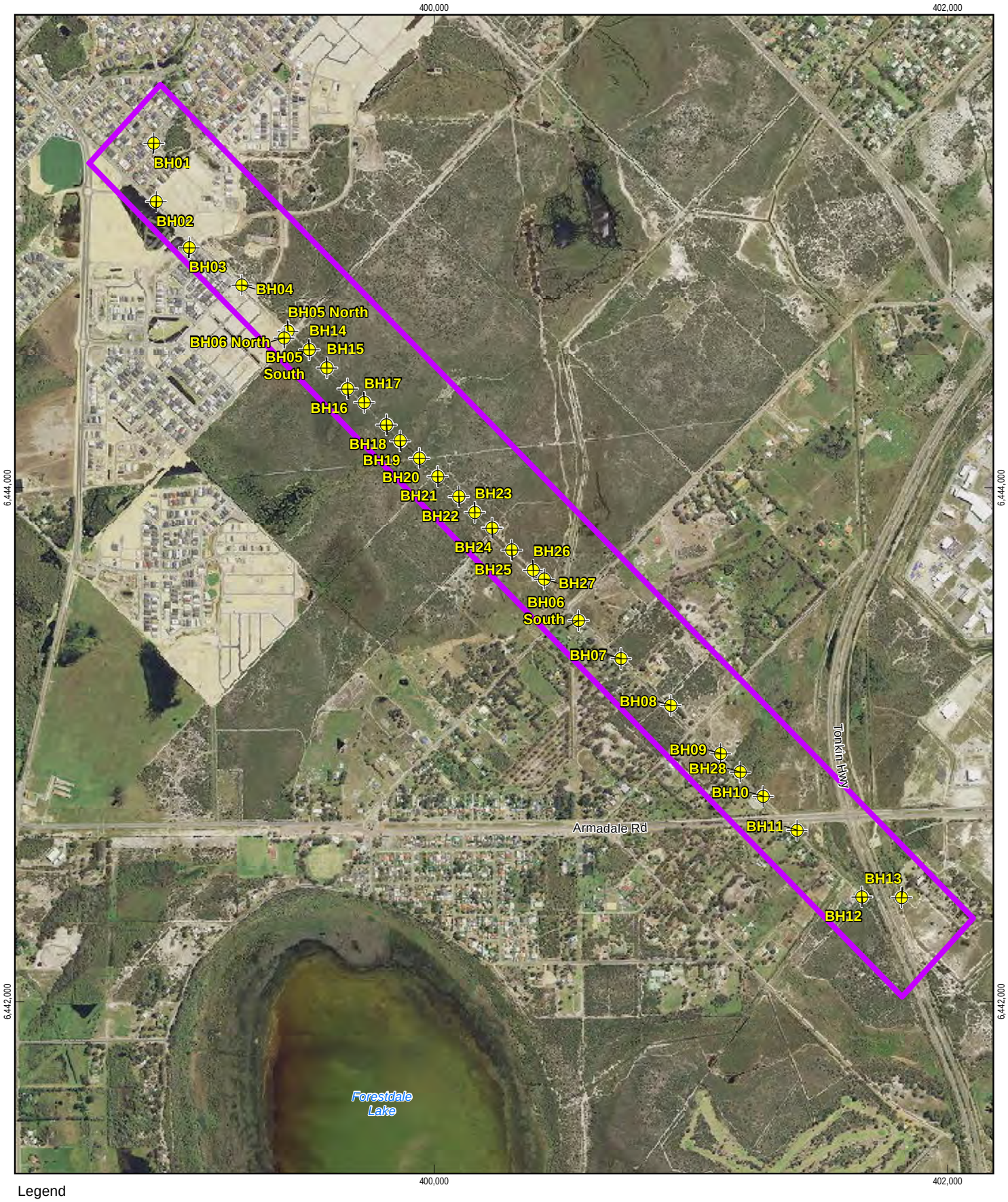
Data source: GHD: Pressure Main - 20140415, Section - 20140415; DEC: Acid Sulfate Soil Risk - 20120229; Landgate: Virtual Mosaic - 20140416, Road - 20140416. Created by: mczekaj



Legend

Groundwater Well

Balannup A WWPS and Keane Road Pressure Main Works Site

1: 20,000 (at A4)

0 100 200 400 600 800

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Grid: Map Grid of Australia 1994, Zone 50

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Water Corporation
Keane Road Pressure Main
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Geotechnical and ASS Investigation Locations

Figure 5

Job Number 61-29471
Revision 0
Date 17 Apr 2014

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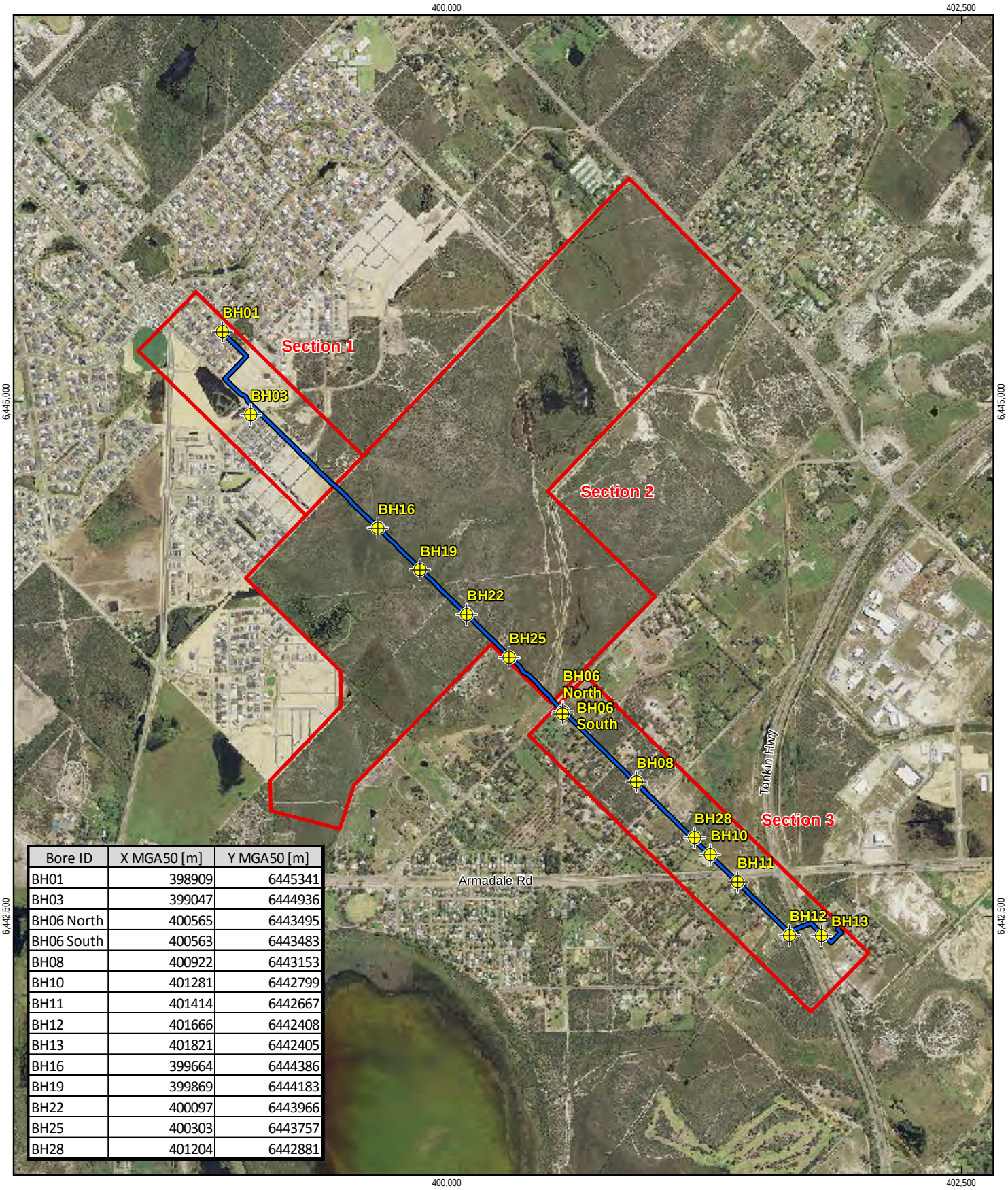
Data source: GHD: Balannup A WWPS and Keane Road Pressure Main Works Site - 20140415, Groundwater Well - 20140417; Landgate: Road Names - 20140416, Virtual Mosaic - 20140416. Created by: mczekaj



Bore ID	X MGA50 [m]	Y MGA50 [m]
BH01	398909	6445341
BH03	399047	6444936
BH06 North	400565	6443495
BH06 South	400563	6443483
BH08	400922	6443153
BH10	401281	6442799
BH11	401414	6442667
BH12	401666	6442408
BH13	401821	6442405
BH16	399664	6444386
BH19	399869	6444183
BH22	400097	6443966
BH25	400303	6443757
BH28	401204	6442881

Legend

Selected Groundwater Well

Section

Pressure Main

1: 25,000 (at A4)

0 125 250 500 750 1,000

Metres

Map Projection: Transverse Mercator

Horizontal Datum: Geocentric Datum of Australia

Grid: Map Grid of Australia 1994, Zone 50

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Keane Road Pressure Main

Draft Acid Sulfate Soil and Dewatering Management Plan

Groundwater Well Locations

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Date 17 Apr 2014

Figure 6

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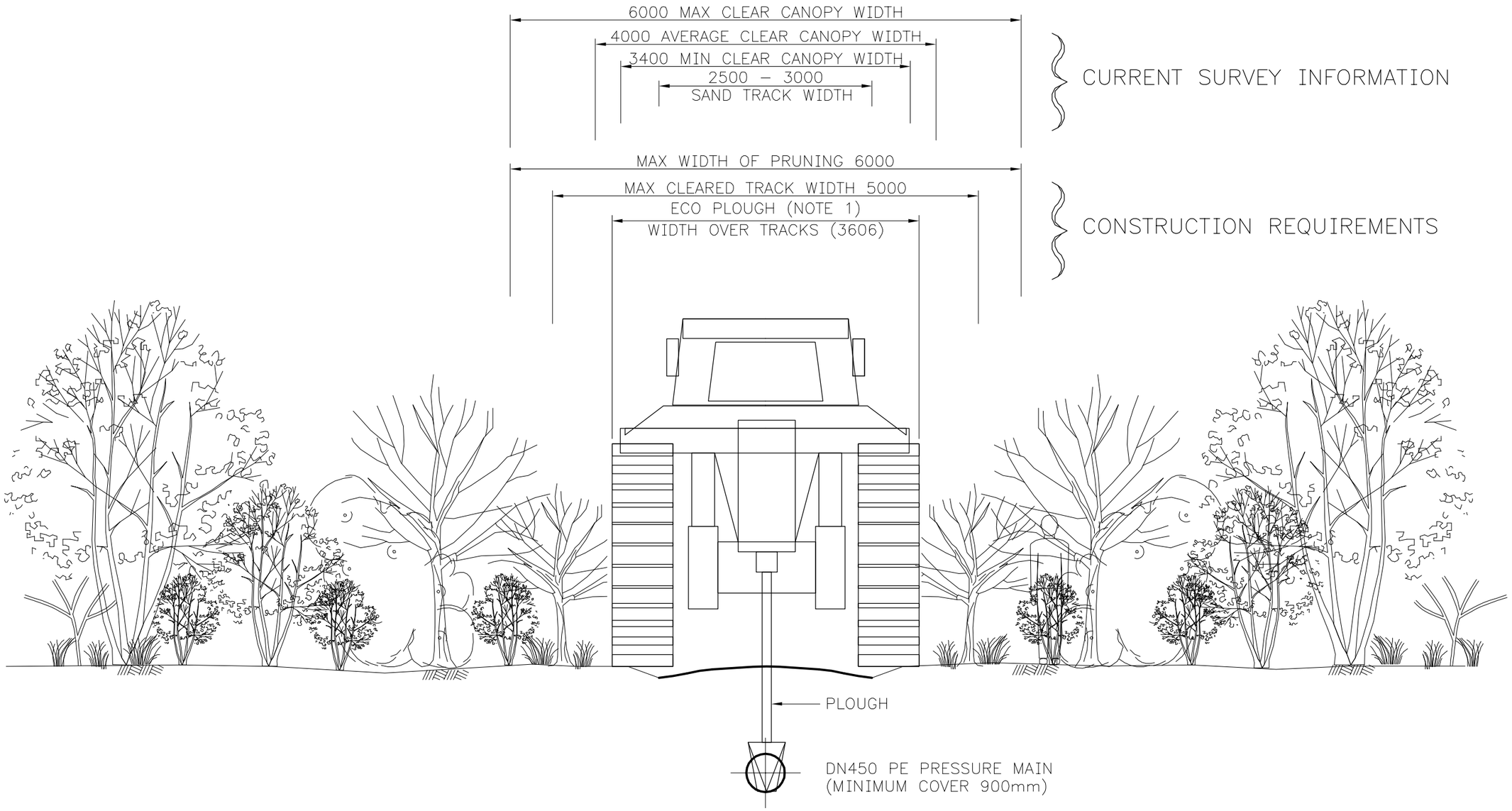
Data source: GHD: Pressure Main - 20140415, Section - 20140415, Selected Groundwater Well - 20140416; Landgate: Virtual Mosaic - 20140416, Road Names - 20140416. Created by: mczekaj

Appendix B – Preliminary Design Drawings



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FOR GENERAL NOTES REFER DRG HW91–2–13–1

NOTE
1. DIMENSIONS BASED ON CATERPILLAR D11

1000 500 0 1000 2000 3000 mm (1:50)

DES CALC E. BISHOP DES CHD G. DUNLOP	RECOMMENDED 06/02/2014 P.G. SPENCER (SIGNED) for CONSULTANT JOB MANAGER	METROPOLITAN WASTEWATER WAPC 127155 BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM DN450 PE PRESSURE MAIN – BUSH FOREVER AREA TYPICAL SECTION OF ECO PLOUGH THROUGH BUSH FOREVER AREA
DRN K.BOSMAN Q.C. CHD R. SPILLANE	APPROVED 06/02/2014 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR	FILE JT1 201202141 VO1 · PLAN CAD HW91–2–13–2 · ISSUE A · PROJECT C–S01249

ORIGINAL SHEET SIZE A3

MF

283
394

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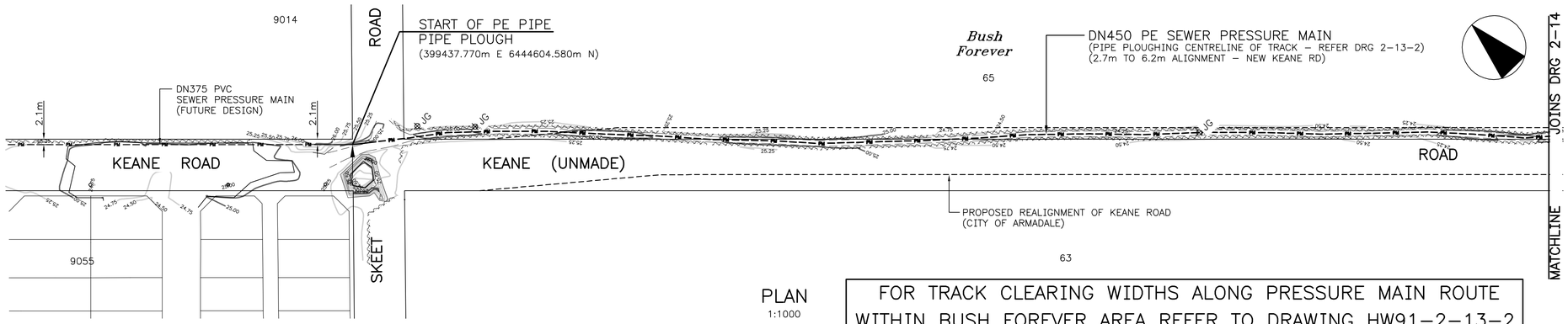
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	
EXISTING BUSHLINE	
JACKSONIA GRACILLIMA LOCATION	JG

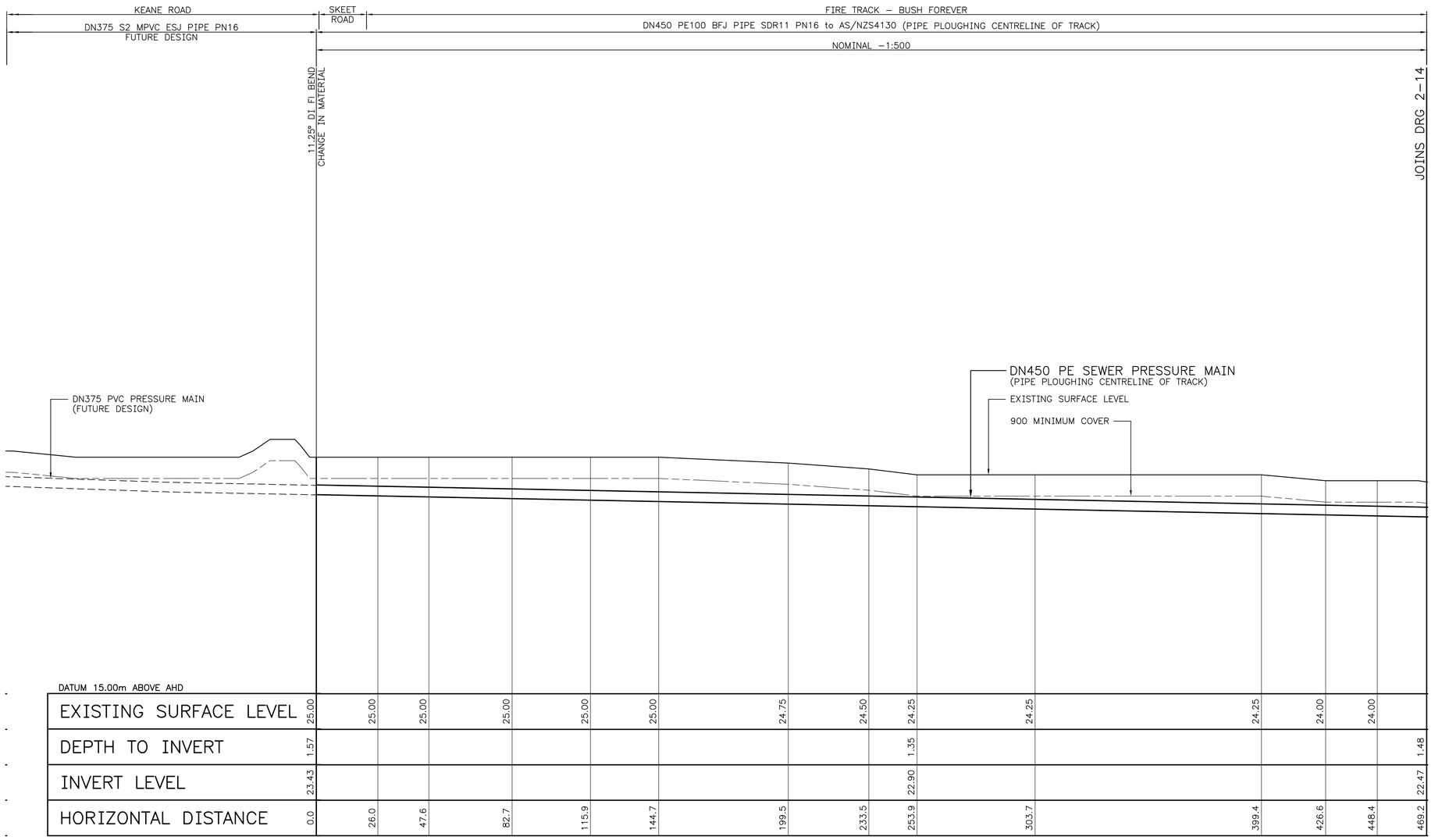
GENERAL NOTES

1. PRESSURE MAIN SHALL BE SET OUT AS SHOWN ON THE DRAWINGS WITH REAL TIME RECORDING OF ALIGNMENT GPS CO-ORDINATES, INCLUDING DEPTH, USING IN-VEHICLE ELECTRONIC EQUIPMENT.
2. NO DEVIATION FROM THE ALIGNMENT SHOWN IS ACCEPTABLE UNLESS APPROVED IN WRITING BY THE SUPERINTENDENT.
3. PRESSURE MAIN SHALL HAVE A MINIMUM DEPTH OF COVER OF 900mm.
4. PRESSURE MAIN SHALL BE LAID TO UNIFORM GRADE BETWEEN INVERT LEVELS SHOWN.
5. PRIOR TO CONSTRUCTION OF THE PRESSURE MAIN THE EXISTING DRAIN AS SHOWN ON DRAWING HW91-2-15 SHALL BE REMOVED TO 3 METRES EITHER SIDE OF THE TRACK CENTRELINE. THE DRAIN SHALL BE REINSTALLED AT ITS ORIGINAL LEVELS ON COMPLETION OF INSTALLATION OF THE PRESSURE MAIN.
6. PE PRESSURE MAIN TO BE AS/NZS4130, SERIES 1. PRESSURE MAIN PIPES TO BE COLOURED BLACK.
7. DEFLECTION AT BENDS SHALL BE ACHIEVED BY BENDING THE PIPE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
8. PE PIPES SHALL BE BUTT FUSION WELDED.
9. NO CONSTRUCTION OR LAYDOWN AREAS TO BE CREATED WITHIN THE 'BUSH FOREVER' AREA OTHER THAN WITHIN THE APPROVED CLEARED TRACK ALIGNMENT.
10. NO CLEARING OR DAMAGE TO BUSHLAND SHALL OCCUR OUTSIDE THE APPROVED CLEARED TRACK ALIGNMENT WITHIN THE 'BUSH FOREVER' AREA.
11. JACKSON GRACILLIMA, AS LOCATED ON THE PLANS, ARE NOT TO BE REMOVED OR DAMAGED DURING CONSTRUCTION.
12. ANY CONSTRAINTS TO CONSTRUCTION OR DAMAGE TO EXISTING FLORA TO BE REPORTED IMMEDIATELY TO THE SUPERINTENDENT.
13. NO DEWATERING OR OPEN TRENCHING (OTHER THAN DRAIN CROSSING INDICATED ON DRG 2-15) TO BE CARRIED OUT WITHIN THE BUSH FOREVER AREA.



PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL	25.00	25.00	25.00	25.00	25.00	25.00	24.75	24.50	24.25	24.25	24.25	24.00	24.00	
DEPTH TO INVERT	1.57								1.35					1.48
INVERT LEVEL	23.43								22.90					22.47
HORIZONTAL DISTANCE	0.0	26.0	47.6	82.7	115.9	144.7	199.5	233.5	253.9	303.7	399.4	426.6	448.4	469.2

LONGITUDINAL SECTION

HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)

10.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC E. BISHOP	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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RECOMMENDED	06/02/2014
P.G. SPENCER (SIGNED)	
for CONSULTANT JOB MANAGER	
APPROVED	06/02/2014
P.G. SPENCER (SIGNED)	
CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
DN450 PE PRESSURE MAIN - BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION - SHEET 1 OF 3

FILE	PLAN	CAD	ISSUE
JT1 201202141 V01	HW91-2-13-1		A
PROJECT C-S01249			MF

ORIGINAL SHEET SIZE A1

566
810

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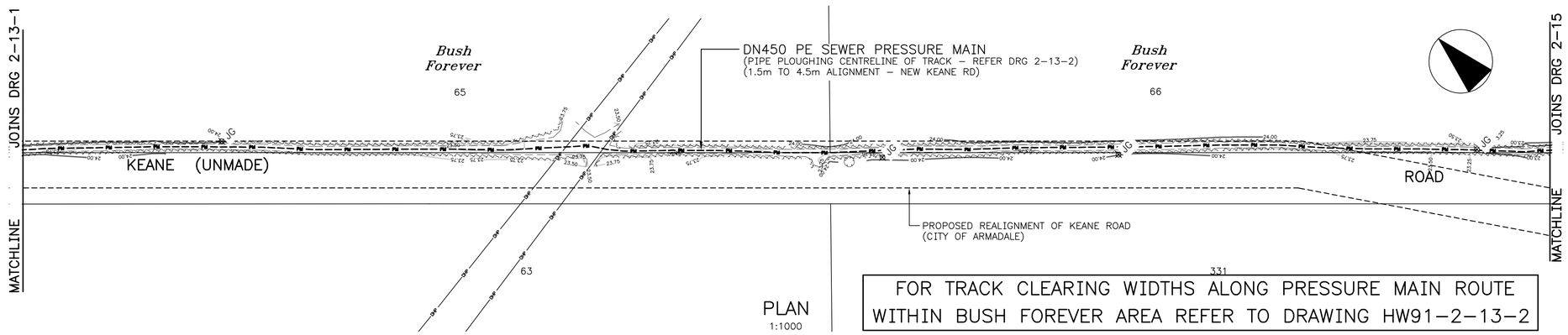
61\29471\CADD\HW91\HW91-002-013-01A 06/02/2014



PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91-2-13-2

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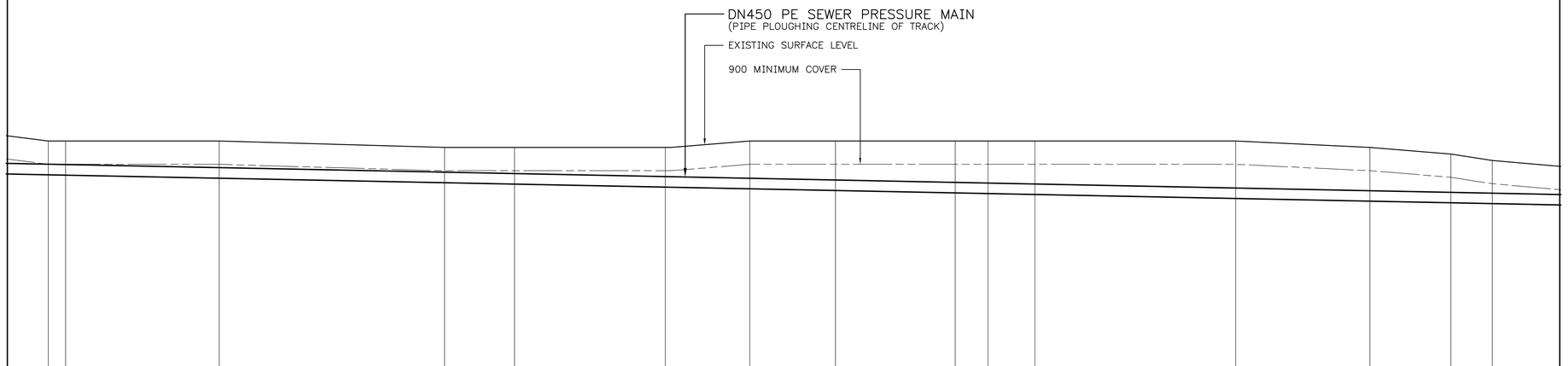
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	
EXISTING BUSHLINE	
JACKSONIA GRACILLIMA LOCATION	JG

FOR GENERAL NOTES REFER DRG HW91-2-13-1

FIRE TRACK – BUSH FOREVER
DN450 PE100 BFJ PIPE SDR11 PN16 to AS/NZS4130 (PIPE PLOUGHING CENTRELINE OF TRACK)
NOMINAL –1:500



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL		23.75	23.75	23.75	23.50	23.50	23.50	23.75	23.75	23.75	23.75	23.75	23.75	23.50	23.25	23.00	22.77	
DEPTH TO INVERT	1.48	1.31															1.50	
INVERT LEVEL	22.47	22.44															21.27	
HORIZONTAL DISTANCE	469.2	485.0	491.6	551.0	638.9	665.2	723.5	756.1	789.3	835.5	848.3	866.3	944.0	995.8	1027.1	1043.2	1069.2	

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
10.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY: GHD 2661551 V01
ASCON SURVEY: NONE
VERTICAL DATUM: AHD
COORDINATE SYS: MGA94-50
DES REF: GHD 61-29471
DES CALC: E. BISHOP
DES CHD: G. DUNLOP
DRN: K.BOSMAN
Q.C. CHD: R.SPILLANE
NORTH POINT

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BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION – SHEET 2 OF 3

FILE JT1 201202141 V01
PROJECT C-S01249
PLAN HW91-2-14
CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

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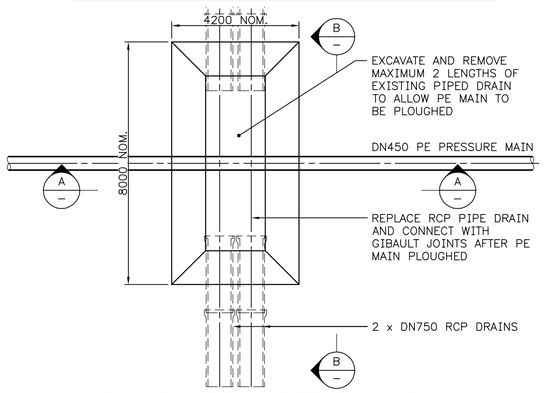
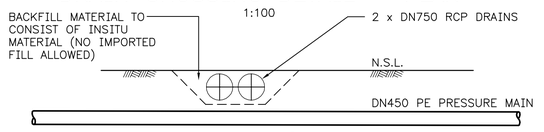
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	
EXISTING BUSHLINE	
JACKSONIA GRACILLIMA LOCATION	JG

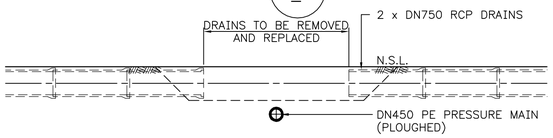
FOR GENERAL NOTES REFER DRG HW91–2–13–1



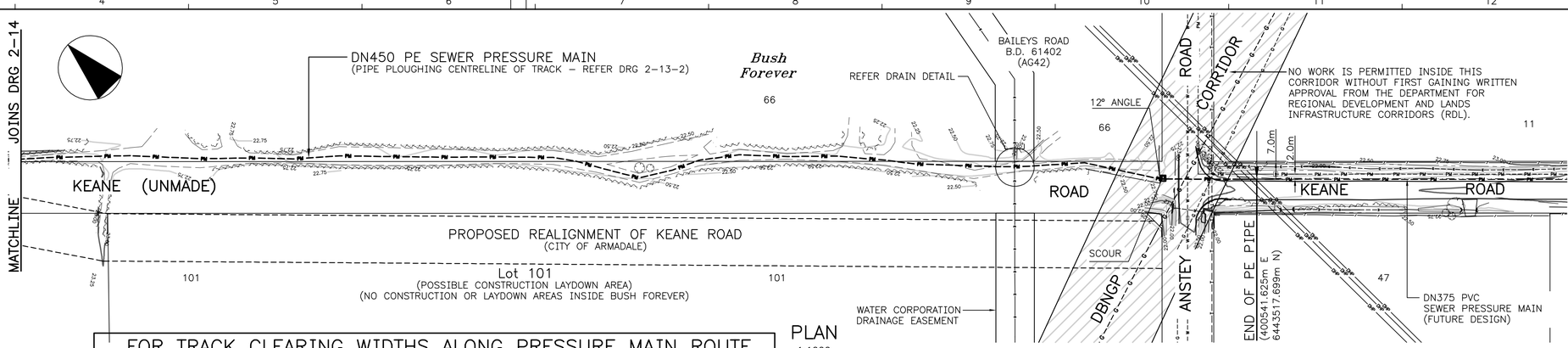
DRAIN CROSSING DETAIL – PLAN
1:100



SECTION A

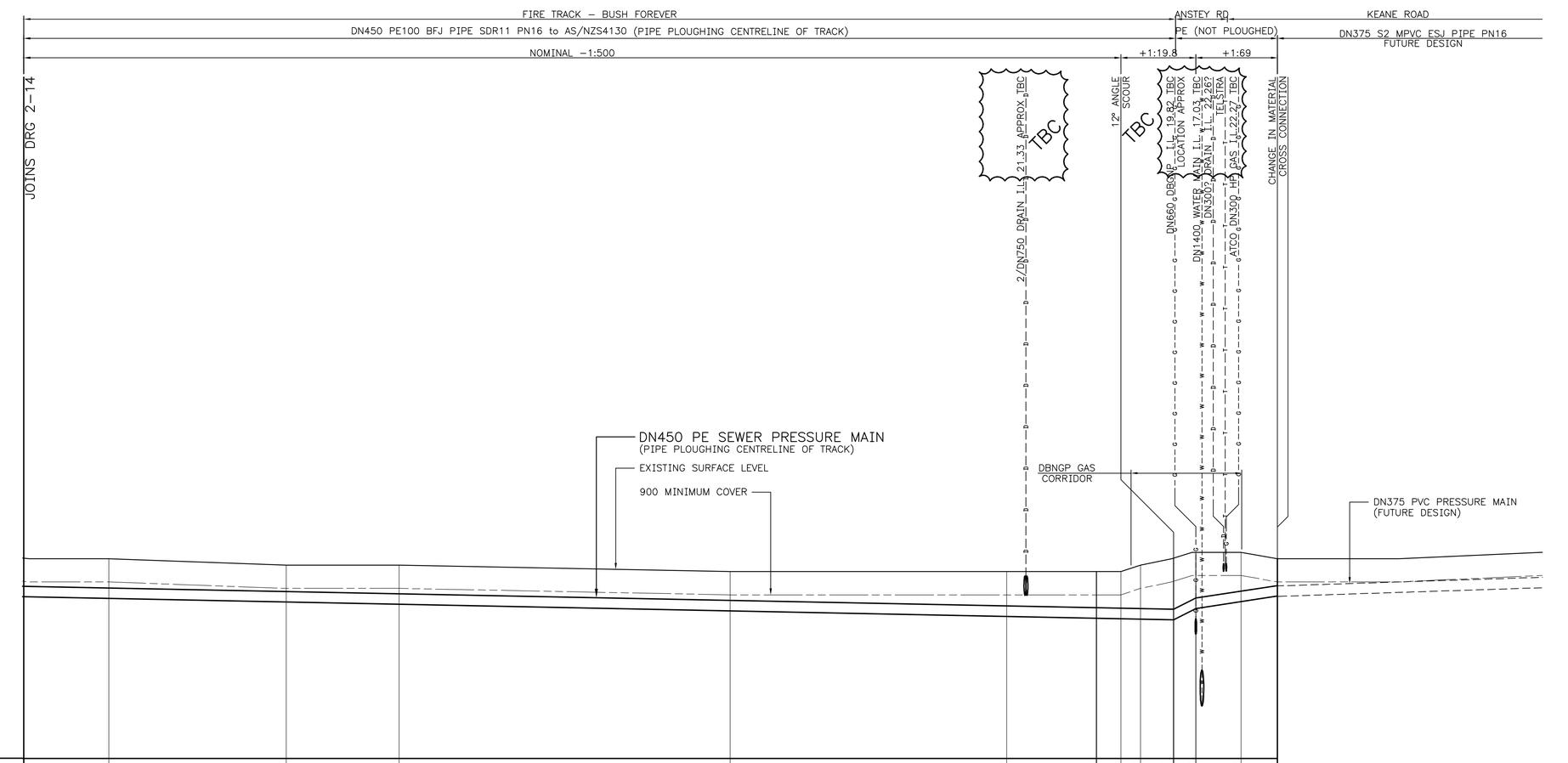


SECTION B



PLAN
1:1000

FOR TRACK CLEARING WIDTHS ALONG PRESSURE MAIN ROUTE WITHIN BUSH FOREVER AREA REFER TO DRAWING HW91–2–13–2



DATUM 15.00m ABOVE AHD

EXISTING SURFACE LEVEL	22.77	22.75	22.50	22.50	22.25	22.25		22.25	22.50	22.77	23.00	23.00	22.75
DEPTH TO INVERT	1.50		1.43							2.39	2.18		1.45
INVERT LEVEL	21.27		21.07							20.38	20.82		21.30
HORIZONTAL DISTANCE	1069.2	1102.2	1171.1	1214.9	1343.5	1450.8	1485.7	1495.2	1502.8	1515.7	1522.8	1541.9	1556.0

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

(1:1000) (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC E. BISHOP	NORTH POINT
	COORDINATE SYS MGA94–50	DES CHD G. DUNLOP	
ASCON SURVEY NONE	DES REF GHD 61–29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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for CONSULTANT JOB MANAGER	
APPROVED	06/02/2014
P.G. SPENCER (SIGNED)	
CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
DN450 PE PRESSURE MAIN – BUSH FOREVER AREA
PLAN AND LONGITUDINAL SECTION – SHEET 3 OF 3

FILE JT1 201202141 V01	PLAN HW91–2–15	CAD	ISSUE A
PROJECT C–S01249			MF

ORIGINAL SHEET SIZE A1

566
810

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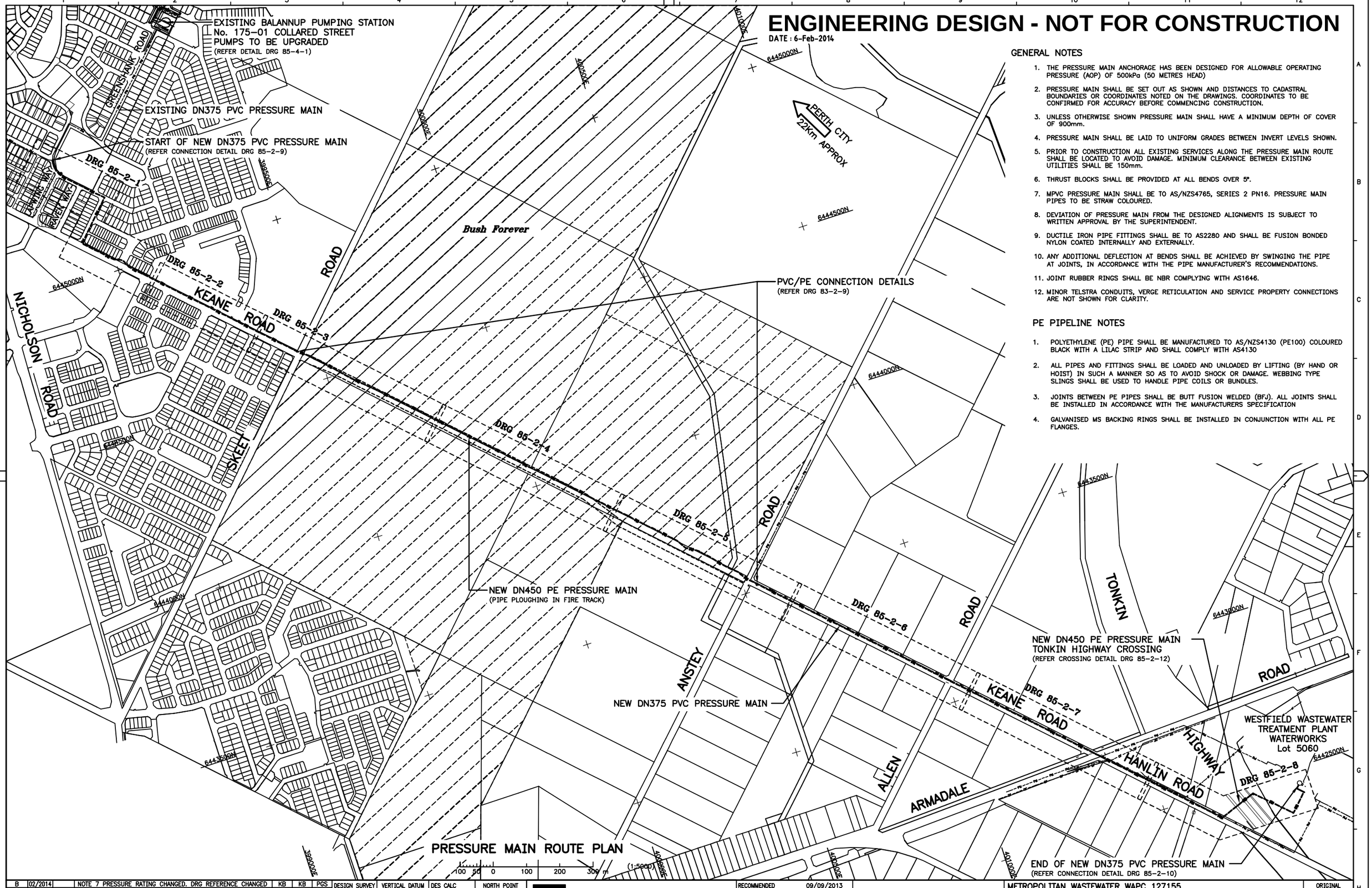
ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 6-Feb-2014



GENERAL NOTES

1. THE PRESSURE MAIN ANCHORAGE HAS BEEN DESIGNED FOR ALLOWABLE OPERATING PRESSURE (AOP) OF 500kPa (50 METRES HEAD)
2. PRESSURE MAIN SHALL BE SET OUT AS SHOWN AND DISTANCES TO CADASTRAL BOUNDARIES OR COORDINATES NOTED ON THE DRAWINGS. COORDINATES TO BE CONFIRMED FOR ACCURACY BEFORE COMMENCING CONSTRUCTION.
3. UNLESS OTHERWISE SHOWN PRESSURE MAIN SHALL HAVE A MINIMUM DEPTH OF COVER OF 900mm.
4. PRESSURE MAIN SHALL BE LAID TO UNIFORM GRADES BETWEEN INVERT LEVELS SHOWN.
5. PRIOR TO CONSTRUCTION ALL EXISTING SERVICES ALONG THE PRESSURE MAIN ROUTE SHALL BE LOCATED TO AVOID DAMAGE. MINIMUM CLEARANCE BETWEEN EXISTING UTILITIES SHALL BE 150mm.
6. THRUST BLOCKS SHALL BE PROVIDED AT ALL BENDS OVER 5°.
7. MPVC PRESSURE MAIN SHALL BE TO AS/NZS4765, SERIES 2 PN16. PRESSURE MAIN PIPES TO BE STRAW COLOURED.
8. DEVIATION OF PRESSURE MAIN FROM THE DESIGNED ALIGNMENTS IS SUBJECT TO WRITTEN APPROVAL BY THE SUPERINTENDENT.
9. DUCTILE IRON PIPE FITTINGS SHALL BE TO AS2280 AND SHALL BE FUSION BONDED NYLON COATED INTERNALLY AND EXTERNALLY.
10. ANY ADDITIONAL DEFLECTION AT BENDS SHALL BE ACHIEVED BY SWINGING THE PIPE AT JOINTS, IN ACCORDANCE WITH THE PIPE MANUFACTURER'S RECOMMENDATIONS.
11. JOINT RUBBER RINGS SHALL BE NBR COMPLYING WITH AS1646.
12. MINOR TELSTRA CONDUITS, VERGE RETICULATION AND SERVICE PROPERTY CONNECTIONS ARE NOT SHOWN FOR CLARITY.

PE PIPELINE NOTES

1. POLYETHYLENE (PE) PIPE SHALL BE MANUFACTURED TO AS/NZS4130 (PE100) COLOURED BLACK WITH A LILAC STRIP AND SHALL COMPLY WITH AS4130
2. ALL PIPES AND FITTINGS SHALL BE LOADED AND UNLOADED BY LIFTING (BY HAND OR HOIST) IN SUCH A MANNER SO AS TO AVOID SHOCK OR DAMAGE. WEBBING TYPE SLINGS SHALL BE USED TO HANDLE PIPE COILS OR BUNDLES.
3. JOINTS BETWEEN PE PIPES SHALL BE BUTT FUSION WELDED (BFJ). ALL JOINTS SHALL BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURERS SPECIFICATION
4. GALVANISED MS BACKING RINGS SHALL BE INSTALLED IN CONJUNCTION WITH ALL PE FLANGES.

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		NOTE 7 PRESSURE RATING CHANGED. DRG REFERENCE CHANGED	KB	KB	PGS

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
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CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
ROUTE PLAN AND GENERAL NOTES

FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C-S01249	HW91-85-1-1		B	A1
				MF

566
810

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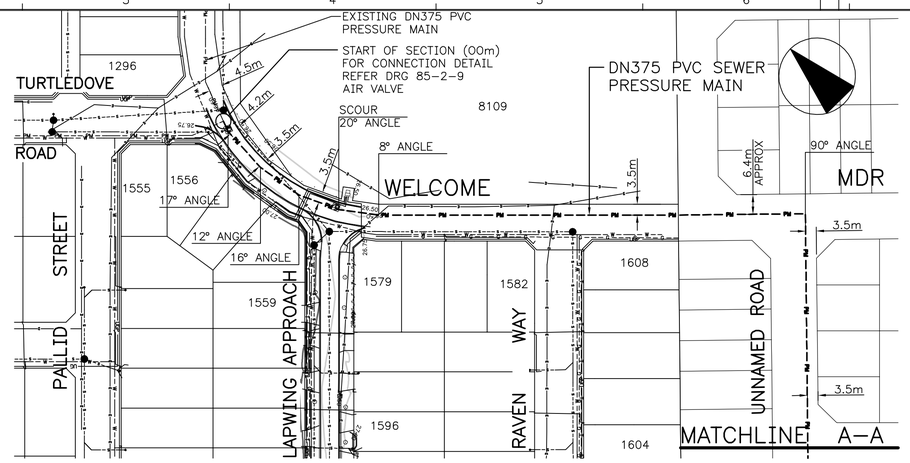
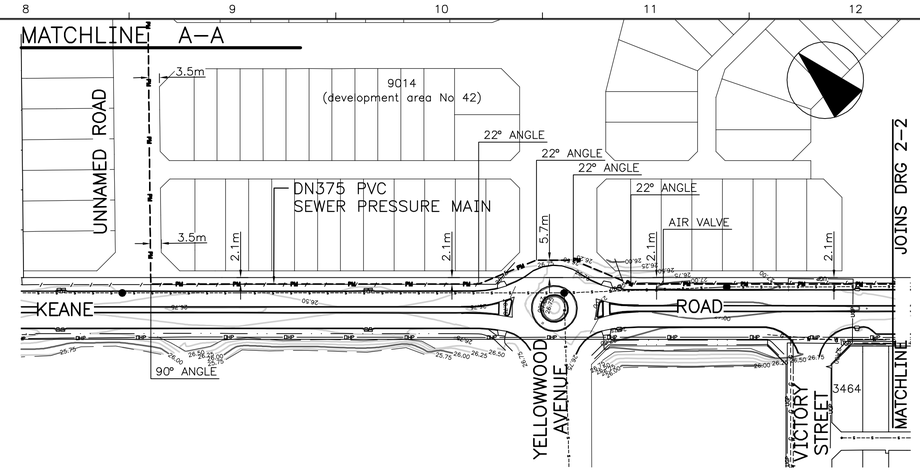


PLAN
1:1000



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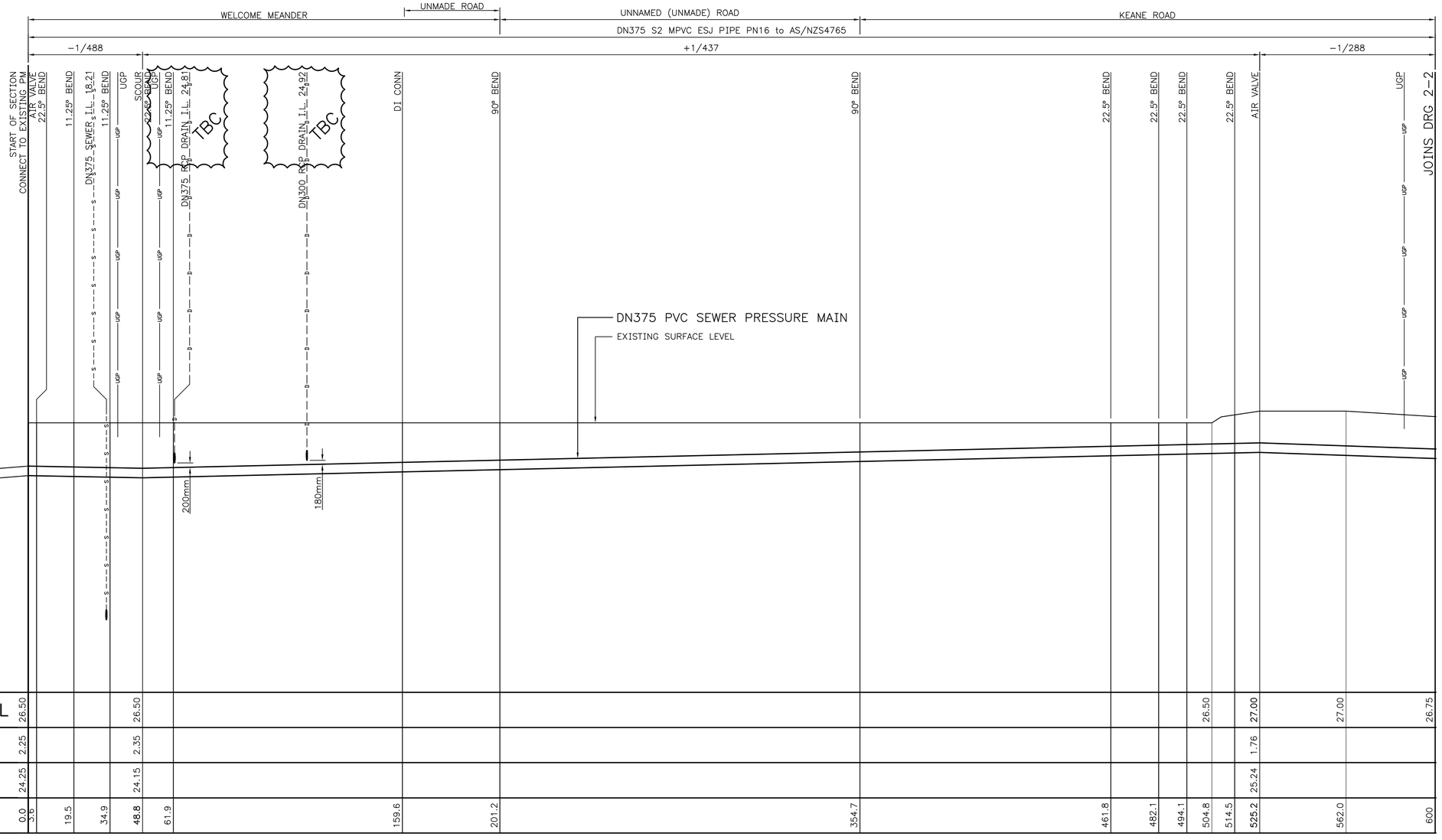
LEGEND

- PROPOSED SEWER PRESSURE MAIN — PM —
- EXISTING WATER MAINS — W —
- EXISTING TELECOMMUNICATION CABLES — T —
- EXISTING OPTIC FIBRE — OF —
- EXISTING UNDERGROUND POWER — UGP —
- EXISTING OVERHEAD POWER — OHP —
- EXISTING GAS MAINS — G —
- EXISTING SEWER MAINS — S —
- EXISTING SEWER PRESSURE MAINS — PM —
- EXISTING DRAINAGE — D —
- EXISTING FENCE — / —
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	26.50				26.50											26.50		27.00		27.00		26.75		
DEPTH TO INVERT	2.25				2.35													1.76						
INVERT LEVEL	24.25				24.15													25.24						
HORIZONTAL DISTANCE	0.0	3.6	19.5	34.9	48.8	61.9	159.6	201.2	354.7	461.8	482.1	494.1	504.8	514.5	525.2	562.0	600							

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION

HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)

10 0.5 0 1 2 3 4 5 6 7 m (1:100)

DATE : 10-Sep-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
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WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 1 OF 8

FILE	PLAN	CAD	ISSUE
PROJECT C-S01249	HW91-85-2-1		A

ORIGINAL SHEET SIZE A1

MF

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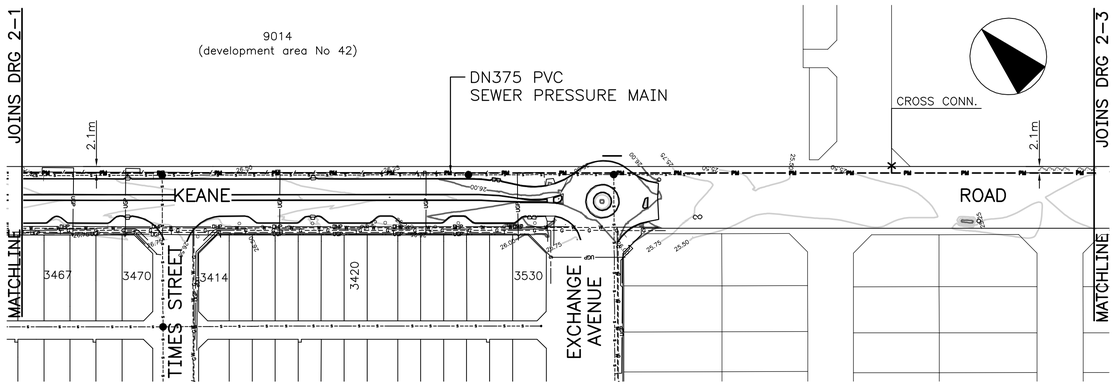

PLAN
1:1000

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EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
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EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	

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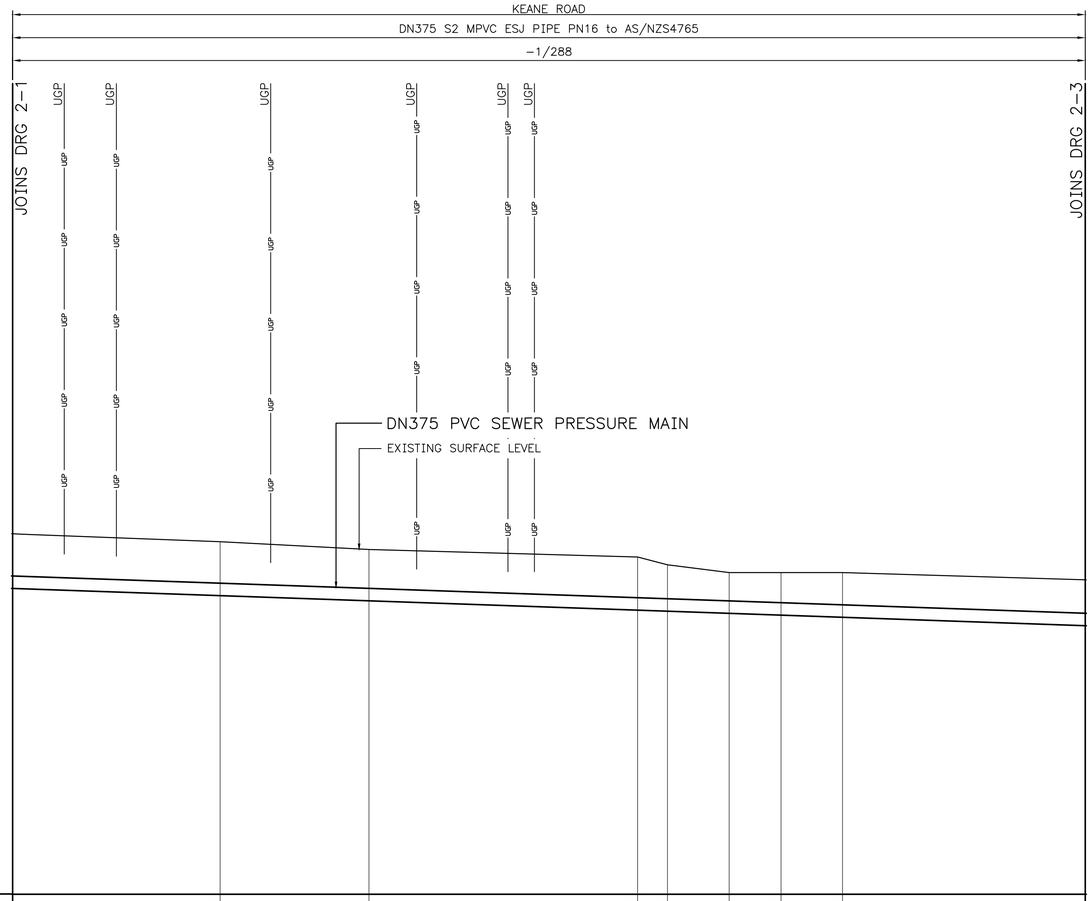

DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	26.75	26.50	26.25	26.00	25.75	25.50	25.50	25.50	25.25
DEPTH TO INVERT									
INVERT LEVEL									
HORIZONTAL DISTANCE	600	667.7	716.3	804.0	813.7	833.8	850.8	870.8	950

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
10 5 0 1 2 3 4 5 6 7 m (1:100)

DATE : 10-Sep-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

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	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
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BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 2 OF 8

FILE	PLAN	CAD	ISSUE
PROJECT C-S01249	HW91-85-2-2		A

ORIGINAL SHEET SIZE A1

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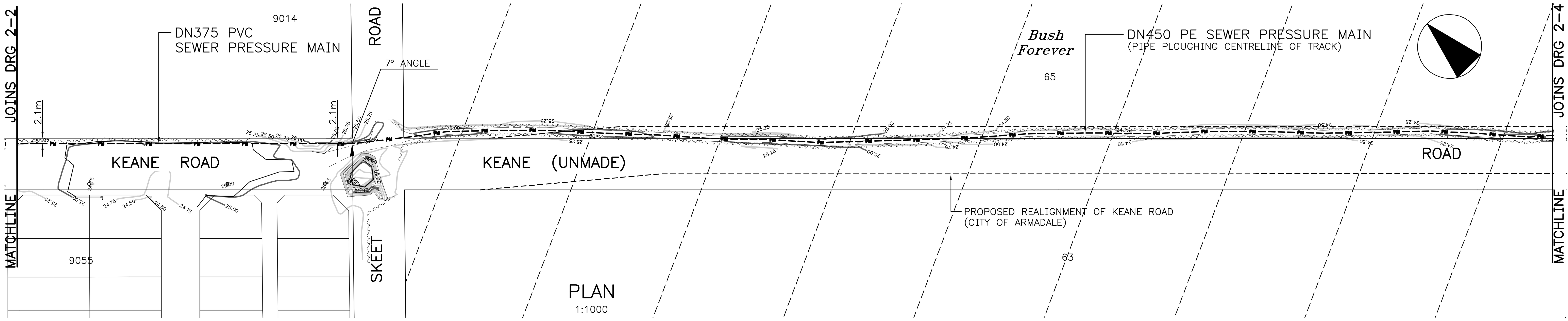

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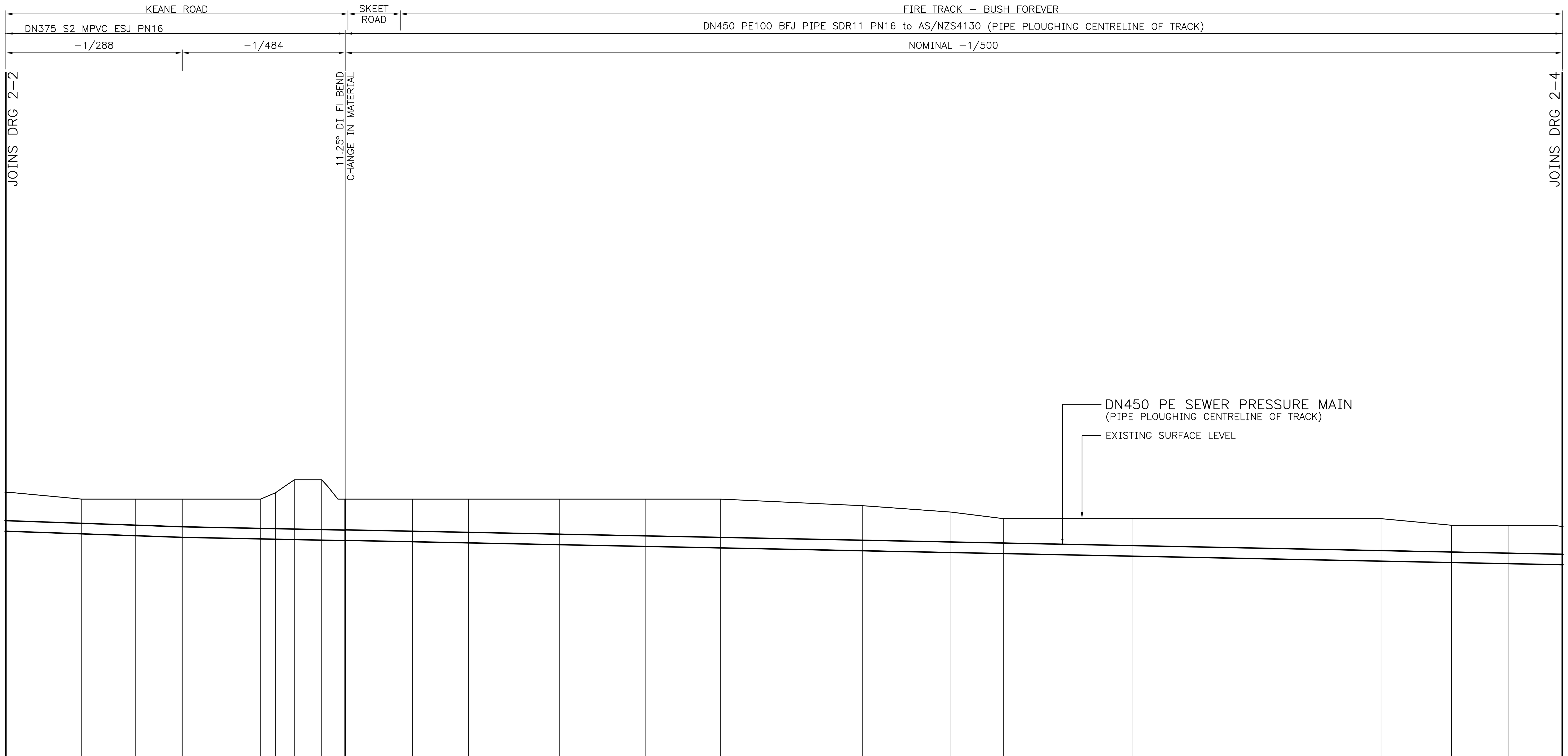
LEGEND

PROPOSED SEWER PRESSURE MAIN	—— PM ——
EXISTING WATER MAINS	— W — W —
EXISTING TELECOMMUNICATION CABLES	— T — T —
EXISTING OPTIC FIBRE	— OF — OF —
EXISTING UNDERGROUND POWER	—— UGP ——
EXISTING OVERHEAD POWER	—— OHP ——
EXISTING GAS MAINS	— G — G —
EXISTING SEWER MAINS	— S — S —
EXISTING SEWER PRESSURE MAINS	—— PM ——
EXISTING DRAINAGE	— D — D —
EXISTING FENCE	—— / ——
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

HORIZONTAL DISTANCE	NATURAL SURFACE LEVEL	DEPTH TO INVERT	INVERT LEVEL
950	25.25		
979.2	25.00		
1000.0	25.00		
1017.9	25.00	1.47	23.53
1048.2	25.00		
1053.9	25.25		
1061.2	25.75		
1071.7	25.75		
1080.8	25.00	1.60 / 1.57	23.40 / 23.43
1106.8	25.00		
1128.4	25.00		
1156.9			
1163.5	25.00		
1196.7	25.00		
1225.5	25.00		
1280.3	24.75		
1314.3	24.50		
1334.7	24.25		
1384.5	24.25		
1480.2	24.25		
1507.4	24.00		
1529.2	24.00		
1550			

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY: GHD 2661551 V01	VERTICAL DATUM: AHD	DES CALC: G.DUNLOP
	COORDINATE SYS: MGA94-50	DES CHD: P.SPENCER
ASCON SURVEY: NONE	DES REF: GHD 61-29471	DRN: K.BOSMAN
		Q.C. CHD: R.SPILLANE

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E permail@ghd.com.au W www.ghd.com.au

RECOMMENDED 09/09/2013
G. DUNLOP (SIGNED)
CONSULTANT JOB MANAGER
APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 3 OF 8

FILE
PROJECT C-S01249
PLAN HW91-85-2-3
CAD
ISSUE A
ORIGINAL SHEET SIZE A1
MF

566
B10

61\29471\CADD\HW91\HW91-085-002-03A 10/09/2013

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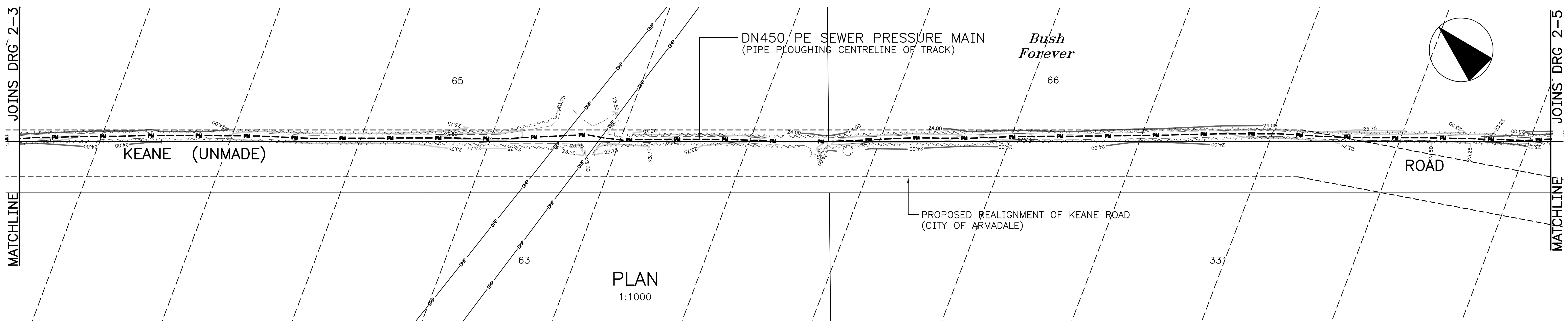
1 2 3 4 5 6 7 8 9 10 11 12



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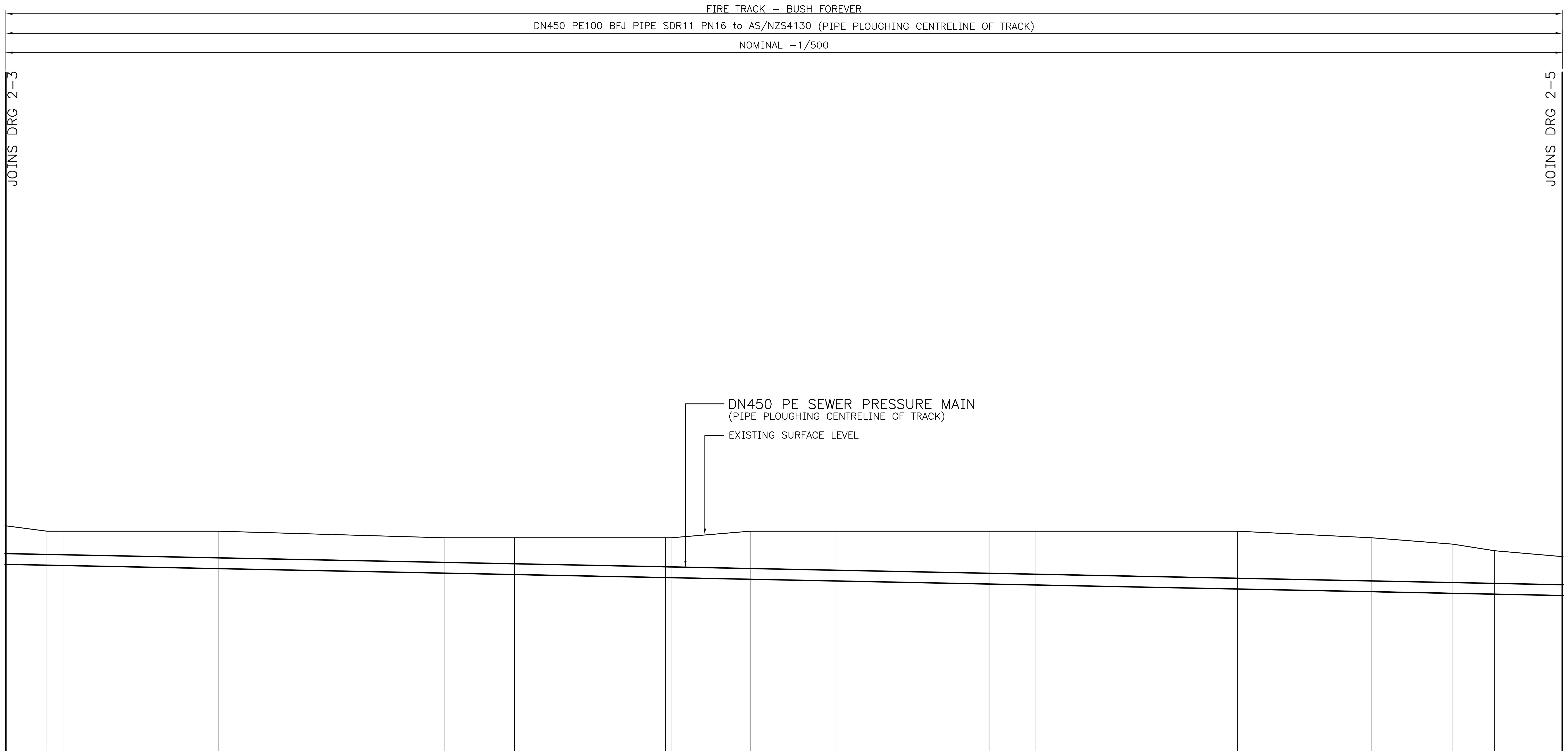
LEGEND

PROPOSED SEWER PRESSURE MAIN	— PM —
EXISTING WATER MAINS	– W – W – W –
EXISTING TELECOMMUNICATION CABLES	– T – T – T –
EXISTING OPTIC FIBRE	– OF – OF – OF –
EXISTING UNDERGROUND POWER	— UGP —
EXISTING OVERHEAD POWER	— OHP —
EXISTING GAS MAINS	– G – G – G – G –
EXISTING SEWER MAINS	– S – S – S – S –
EXISTING SEWER PRESSURE MAINS	— PM —
EXISTING DRAINAGE	– D – D – D –
EXISTING FENCE	— / — / —
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85–1–1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL		23.75	23.75	23.75	23.50	23.50	23.50	23.50	23.75
DEPTH TO INVERT									
INVERT LEVEL									
HORIZONTAL DISTANCE	1550	1565.8	1572.4	1631.8	1719.7	1746.0	1804.3	1806.5	1836.9

NATURAL SURFACE LEVEL	23.75	23.75	23.75	23.75	23.75	23.50	23.25	23.00	22.75
DEPTH TO INVERT									
INVERT LEVEL									
HORIZONTAL DISTANCE	1870.1	1916.3	1929.1	1947.1	2024.8	2076.6	2107.9	2124.0	2150

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

DATE : 10-Sep-2013

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY	VERTICAL DATUM	DES CALC	NORTH POINT
GHD 2661551 V01	AHD	G.DUNLOP	
	COORDINATE SYS MGA94–50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61–29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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E permail@ghd.com.au W www.ghd.com.au

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APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION – SHEET 4 OF 8

ORIGINAL SHEET SIZE A1

FILE | PLAN | CAD | ISSUE A | MF
PROJECT C–S01249
HW91–85–2–4

566
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61\29471\CADD\HW91\HW91–085–002–04A 10/09/2013

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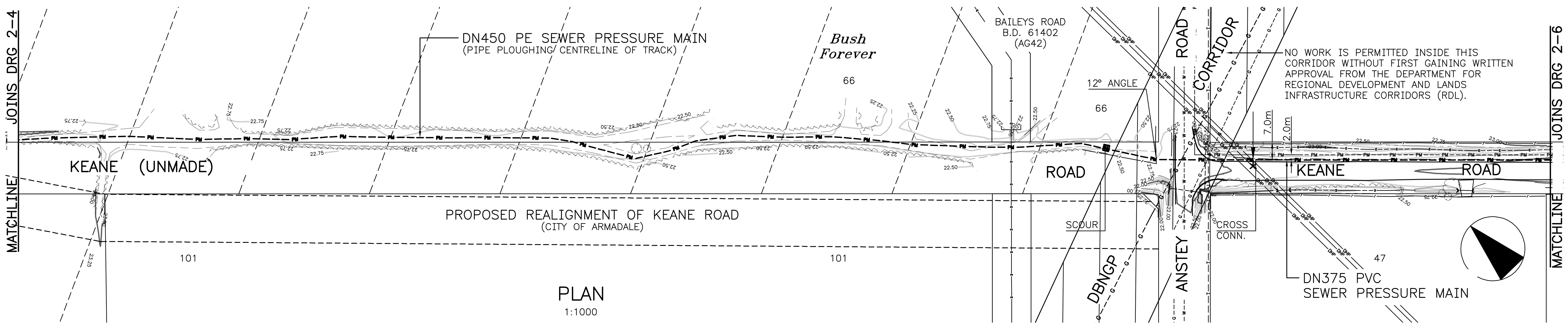

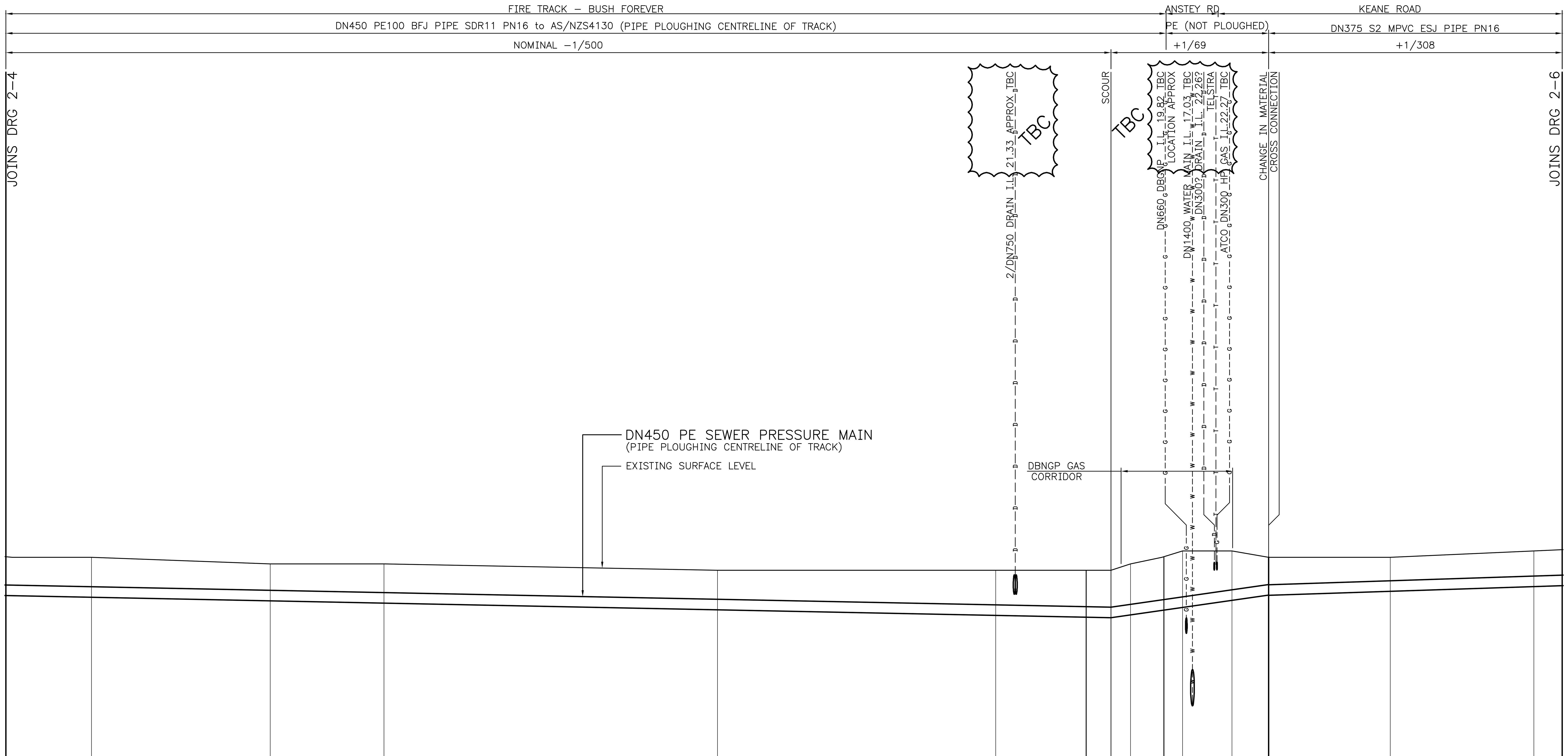

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LEGEND

- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1

DATUM 15.00m ABOVE AHD

HORIZONTAL DISTANCE	NATURAL SURFACE LEVEL	DEPTH TO INVERT	INVERT LEVEL
2150	22.75		
2183.0	22.75		
2251.9	22.50		
2295.7	22.50		
2424.3	22.25		
2531.6	22.25		
2542.1			
2566.5			
2576.0	22.25	1.82	20.42
2583.6	22.50		
2596.5	22.75		
2603.6	23.00		
2622.7	23.00		
2636.8	22.75	1.45 1.46	21.30 21.29
2683.8	22.75		
2739.1	23.00		
2750			

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01 | VERTICAL DATUM AHD | COORDINATE SYS MGA94-50 | DES CALC K.BOSMAN | DES CHD P.SPENCER
ASCON SURVEY NONE | DES REF GHD 61-29471 | DRN K.BOSMAN | Q.C. CHD R.SPILLANE
NORTH POINT

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RECOMMENDED 09/09/2013 G. DUNLOP (SIGNED) CONSULTANT JOB MANAGER
APPROVED 09/09/2013 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 5 OF 8

FILE | PLAN | CAD | ISSUE A
PROJECT C-S01249 | HW91-85-2-5
ORIGINAL SHEET SIZE A1 | MF

61\29471\CADD\HW91\HW91-085-002-05A 10/09/2013

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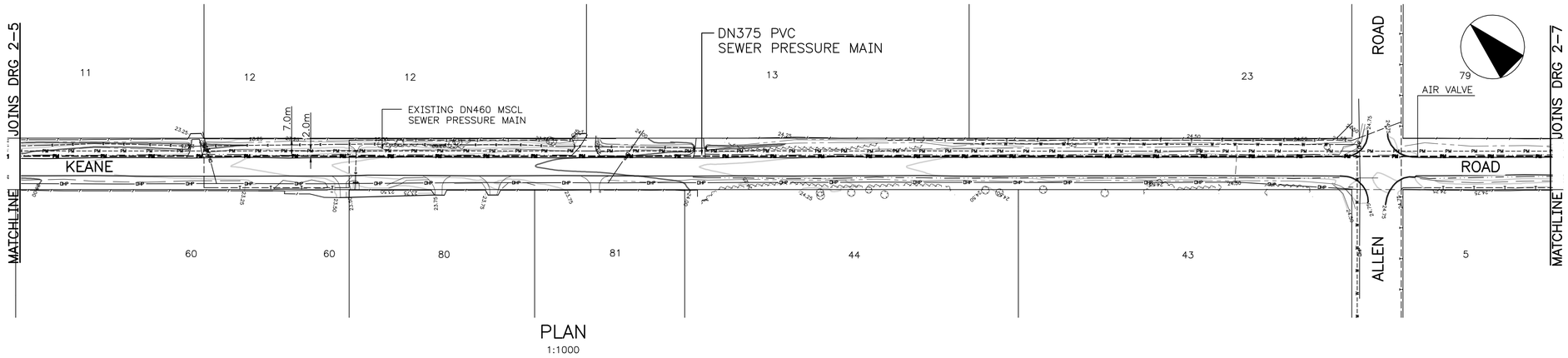

PLAN
1:1000

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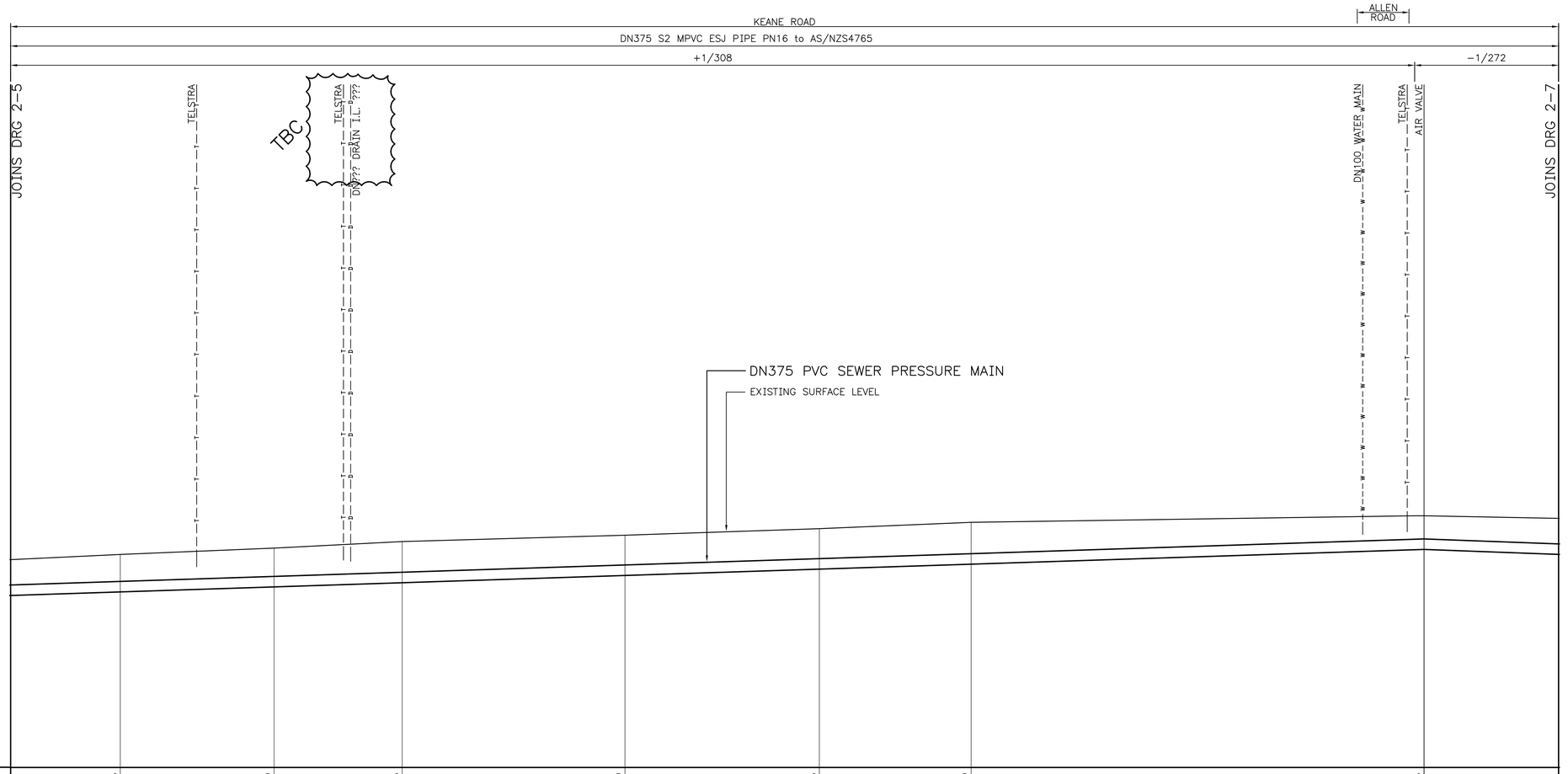
LEGEND

PROPOSED SEWER PRESSURE MAIN	PM
EXISTING WATER MAINS	W
EXISTING TELECOMMUNICATION CABLES	T
EXISTING OPTIC FIBRE	OF
EXISTING UNDERGROUND POWER	UGP
EXISTING OVERHEAD POWER	OHP
EXISTING GAS MAINS	G
EXISTING SEWER MAINS	S
EXISTING SEWER PRESSURE MAINS	PM
EXISTING DRAINAGE	D
EXISTING FENCE	/
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL	23.25	23.50	23.75	24.00	24.25	24.50	24.75		
DEPTH TO INVERT							1.31		
INVERT LEVEL							23.44		
HORIZONTAL DISTANCE	2750	2792.5	2852.1	2901.8	2988.1	3063.5	3122.3	3297.9	3350

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
10.5 0 1 2 3 4 5 6 7 m (1:100)

DATE : 10-Sep-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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CONSULTANT JOB MANAGER	
APPROVED	09/09/2013
P.G. SPENCER (SIGNED)	
CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 6 OF 8

ORIGINAL SHEET SIZE A1

FILE	PLAN	CAD	ISSUE	MF
PROJECT C-S01249	HW91-85-2-6		A	

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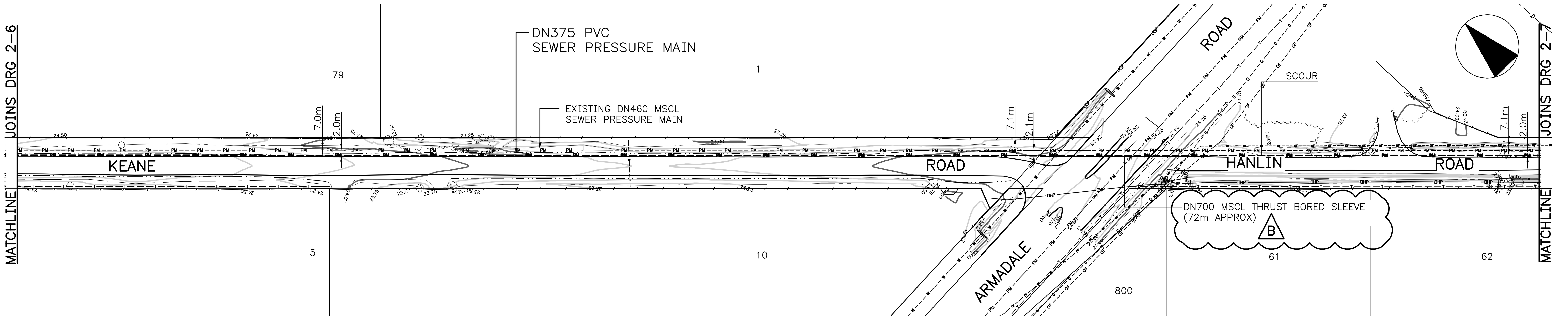

PLAN

1:1000

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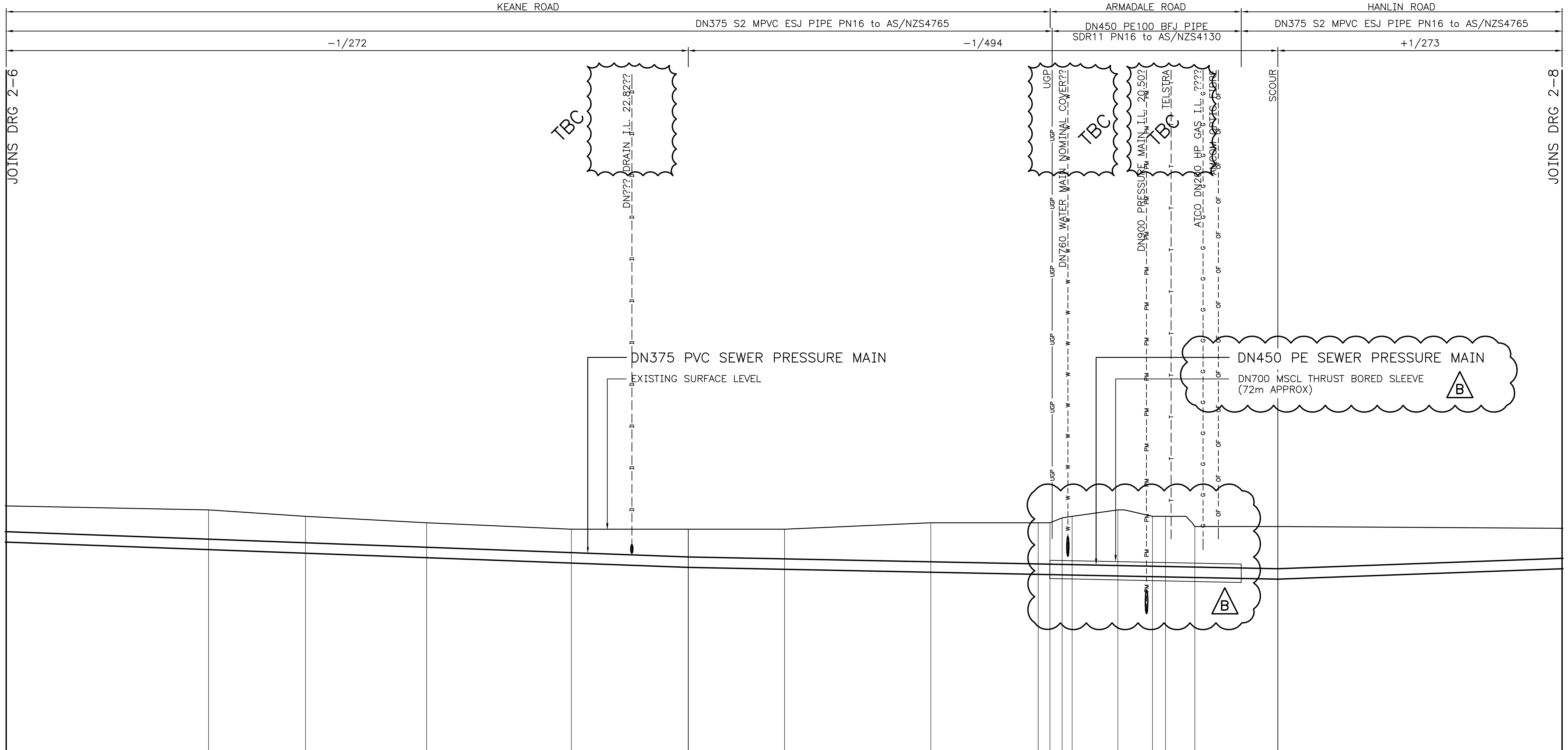
LEGEND

- PROPOSED SEWER PRESSURE MAIN
- EXISTING WATER MAINS
- EXISTING TELECOMMUNICATION CABLES
- EXISTING OPTIC FIBRE
- EXISTING UNDERGROUND POWER
- EXISTING OVERHEAD POWER
- EXISTING GAS MAINS
- EXISTING SEWER MAINS
- EXISTING SEWER PRESSURE MAINS
- EXISTING DRAINAGE
- EXISTING FENCE
- EXISTING TREE

FOR GENERAL NOTES REFER DRG 85-1-1



DATUM 15.00m ABOVE AHD

NATURAL SURFACE LEVEL		24.50	24.25	24.00	23.75		23.75	24.00	24.00	24.00	24.19	24.25	24.50	24.25	24.25	23.85	23.85	
DEPTH TO INVERT						1.47											2.03	
INVERT LEVEL						22.28											21.82	
HORIZONTAL DISTANCE	3350	3428.0	3465.4	3512.2	3567.9	3613.1	3650.2	3706.5	3748.0	3752.5	3757.2	3761.1	3778.7	3792.0	3797.1	3808.4	3840.4	3950

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

DATE : 6-Feb-2014

(1:1000) (1:100)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		TRENCHLESS INSTALLATION SHOWN UNDER ARMADALE RD	KB	KB	PGS

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN	NORTH POINT
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER	
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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CONSULTANT JOB MANAGER
APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 7 OF 8

FILE
PROJECT C-S01249
PLAN CAD HW91-85-2-7
ISSUE B
ORIGINAL SHEET SIZE A1
MF

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61\29471\CADD\HW91\HW91-085-002-07B 06/02/2014

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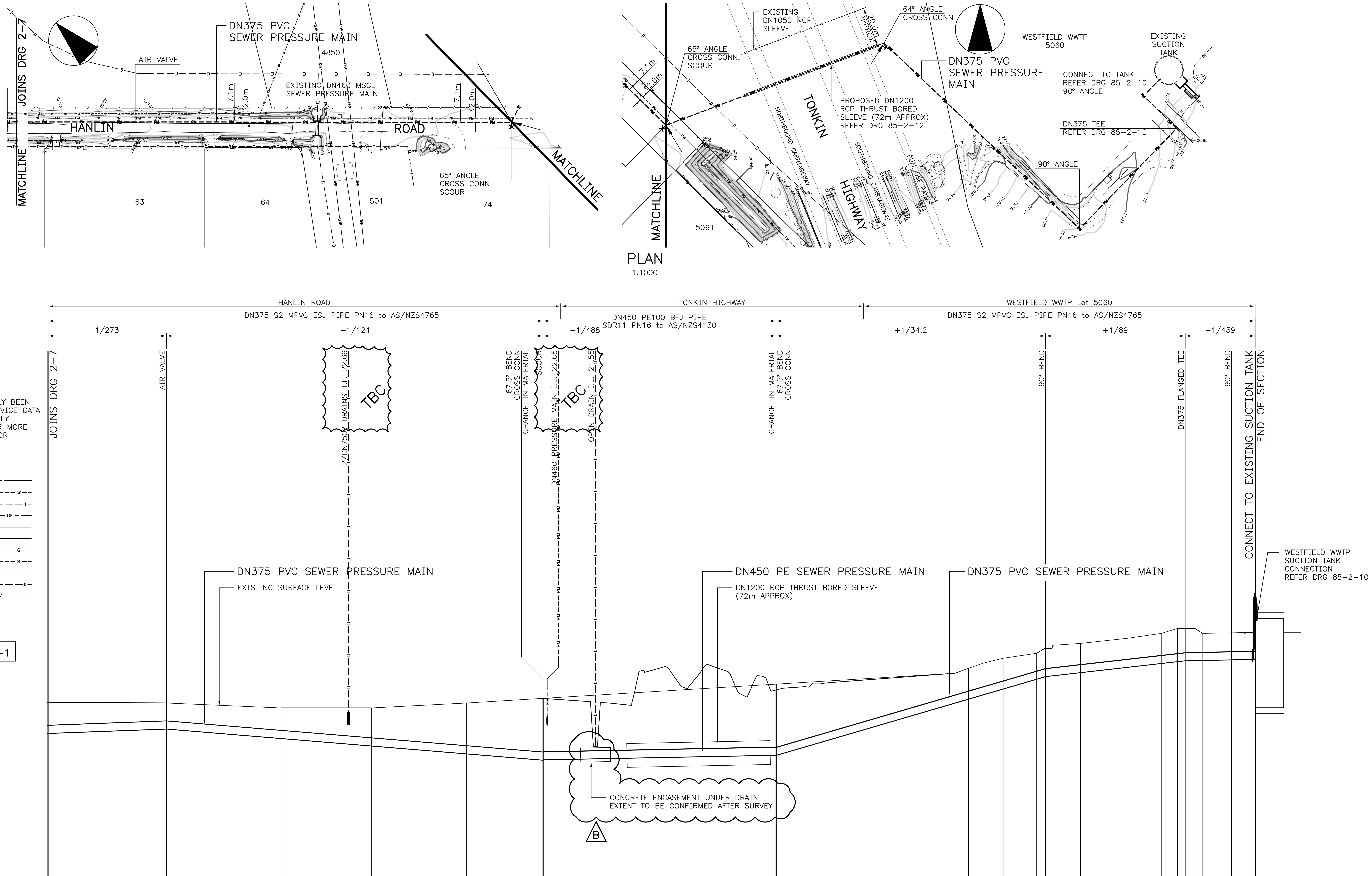

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LEGEND

PROPOSED SEWER PRESSURE MAIN	—— PM ——
EXISTING WATER MAINS	-- W --
EXISTING TELECOMMUNICATION CABLES	-- T --
EXISTING OPTIC FIBRE	-- OF --
EXISTING UNDERGROUND POWER	—— UGP ——
EXISTING OVERHEAD POWER	—— OHP ——
EXISTING GAS MAINS	-- G --
EXISTING SEWER MAINS	-- S --
EXISTING SEWER PRESSURE MAINS	—— PM ——
EXISTING DRAINAGE	-- D --
EXISTING FENCE	—— / ——
EXISTING TREE	

FOR GENERAL NOTES REFER DRG 85-1-1

DATUM 15.00m ABOVE AHD

HORIZONTAL DISTANCE	NATURAL SURFACE LEVEL	DEPTH TO INVERT	INVERT LEVEL
3950			
4009.5	23.75	1.31	22.44
4067.1	23.50		
4112.6	23.50		
4160.4	23.75		
4198.8		3.10 / 3.09	20.88 / 20.89
4316.0		3.28 / 3.29	21.12 / 21.11
4406.0	25.25		
4412.8	25.50		
4420.1	25.75		
4430.2	26.00		
4447.0	26.25		
4451.5	26.50	1.42	25.08
4469.1	26.75		
4492.5	27.00		
4509.7	27.25		
4517.8	27.50		
4521.7		1.63	25.87
4526.5	27.50		
4530.5	27.25		
4545.0			
4556.8	27.30	1.36	25.94

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

LONGITUDINAL SECTION
HORIZONTAL 1:1000, VERTICAL 1:100

10 5 0 10 20 30 40 50 60 70 m (1:1000)
1 0.5 0 1 2 3 4 5 6 7 m (1:100)

DATE : 6-Feb-2014

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		CONCRETE ENCASEMENT ADDED TO DRAIN CROSSING	KB	KB	PGS

DESIGN SURVEY GHD 2661551 V01
ASCON SURVEY NONE
VERTICAL DATUM AHD
COORDINATE SYS MGA94-50
DES REF GHD 61-29471
DES CALC K.BOSMAN
DES CHD P.SPENCER
DRN K.BOSMAN
Q.C. CHD R.SPILLANE
NORTH POINT

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P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
PLAN AND LONGITUDINAL SECTION - SHEET 8 OF 8

FILE
PROJECT C-S01249
PLAN HW91-85-2-8 CAD
ISSUE B
ORIGINAL SHEET SIZE A1
MF

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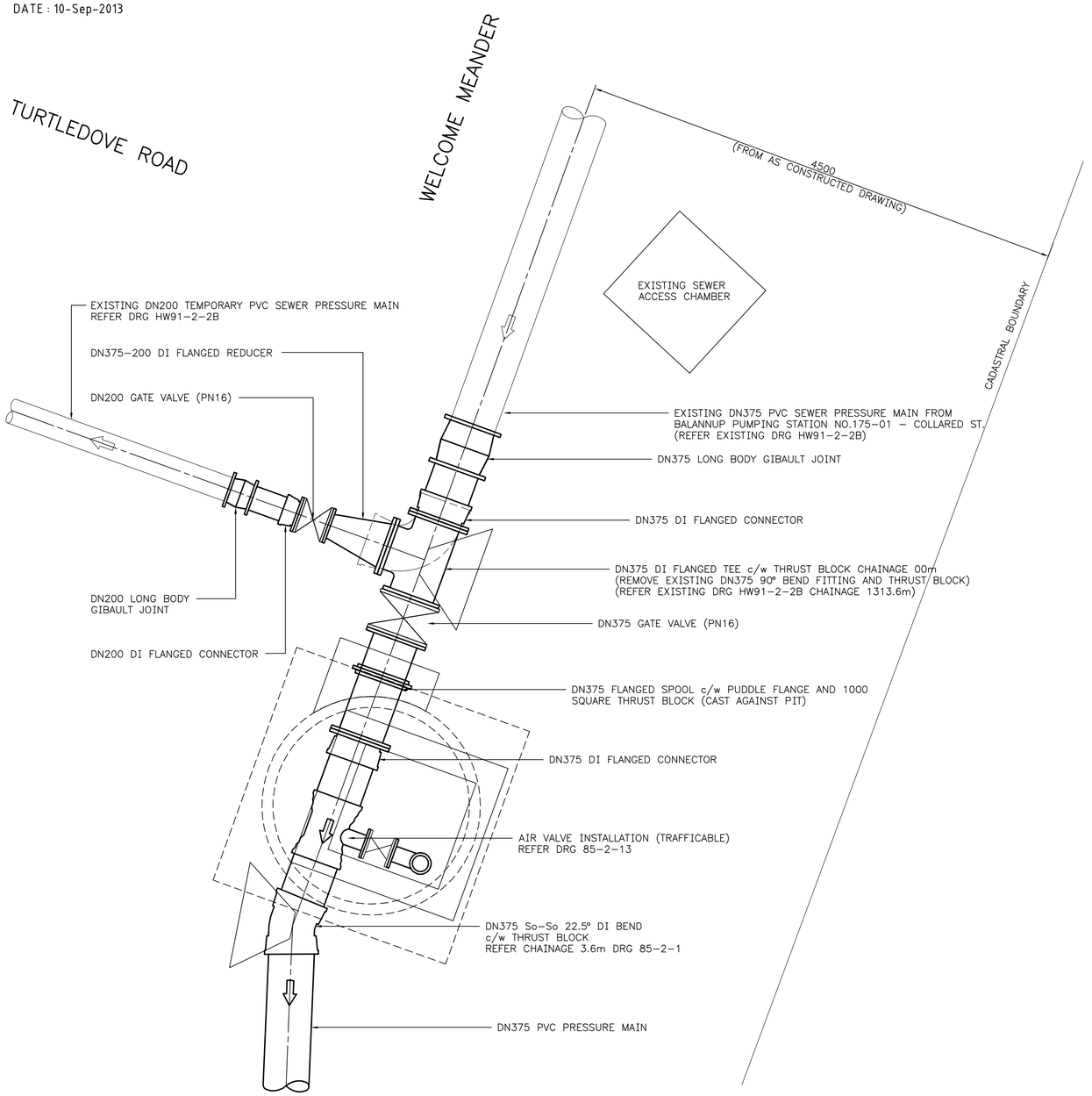
ENGINEERING DESIGN - NOT FOR CONSTRUCTION

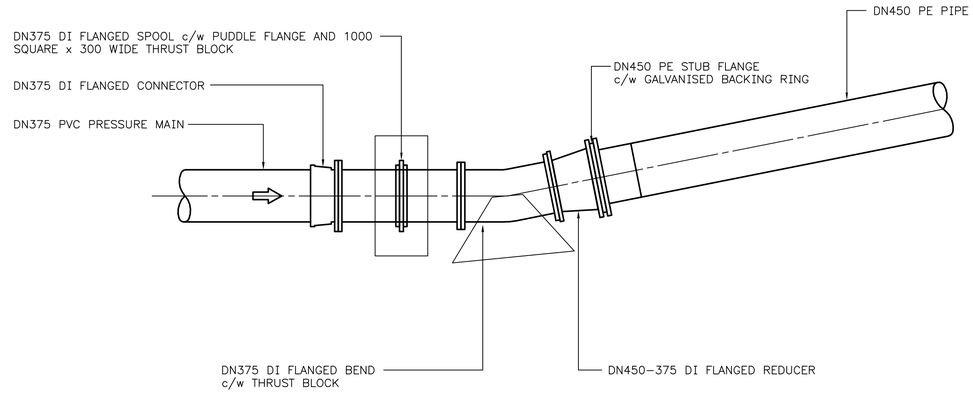
DATE : 10-Sep-2013



CONNECTION TO EXISTING PRESSURE MAIN

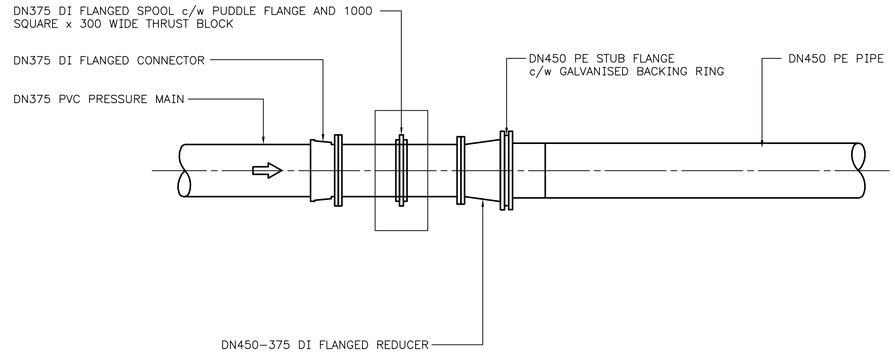
REFER DRG 85-2-1

1:25



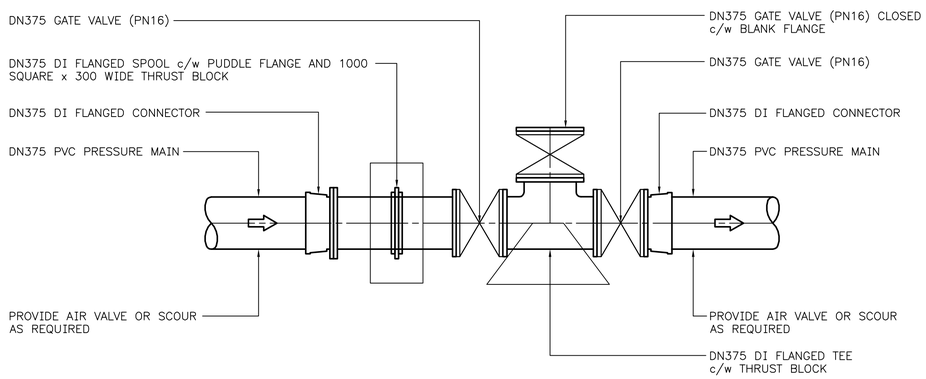
DN375 PVC TO DN450 PE CONNECTION AT A BEND

1:25



DN375 PVC TO DN450 PE STRAIGHT CONNECTION

1:25



TYPICAL CROSS CONNECTION FOR FUTURE PRESSURE MAIN

(4 REQUIRED)

1:25

500 0 500 1000 1500 mm (1:25)

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY: GHD 2661551 V01 | VERTICAL DATUM: NONE | COORDINATE SYS: NONE | ASCON SURVEY: NONE | DES REF: GHD 61-29471

DES CALC K.BOSMAN | DES CHD P.SPENCER | DRN K.BOSMAN | Q.C. CHD R.SPILLANE

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CONSULTANT JOB MANAGER

APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
CONNECTION DETAILS - SHEET 1

FILE: PROJECT C-S01249 | PLAN: HW91-85-2-9 | CAD | ISSUE: A | ORIGINAL SHEET SIZE: A1 | MF

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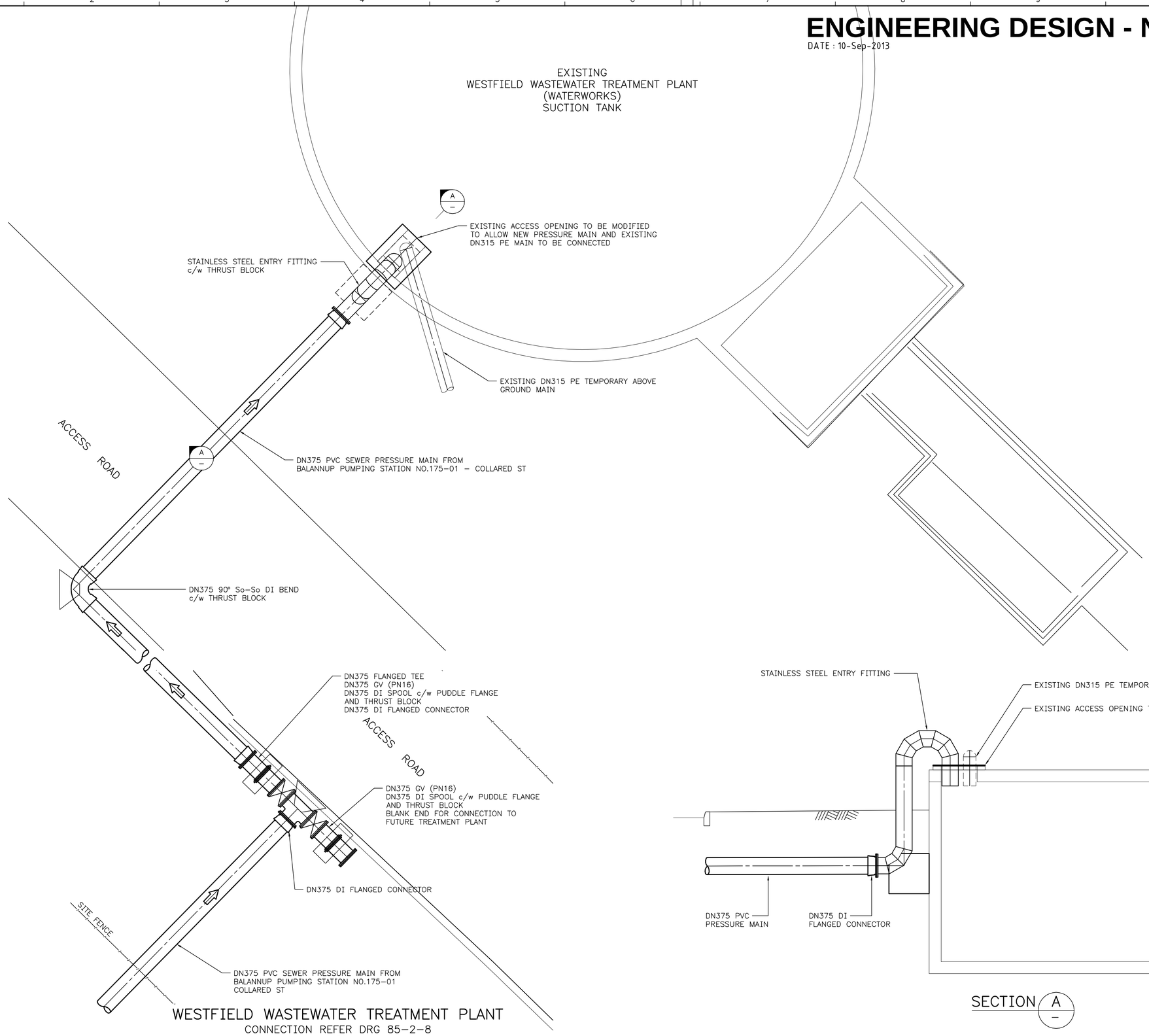
ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013



ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN
	COORDINATE SYS NONE	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

NORTH POINT

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RECOMMENDED	09/09/2013
G. DUNLOP (SIGNED)	
CONSULTANT JOB MANAGER	
APPROVED	09/09/2013
P.G. SPENCER (SIGNED)	
CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
CONNECTION DETAILS - SHEET 2

FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C-S01249	HW91-85-2-10	A	MF	A1

566
810

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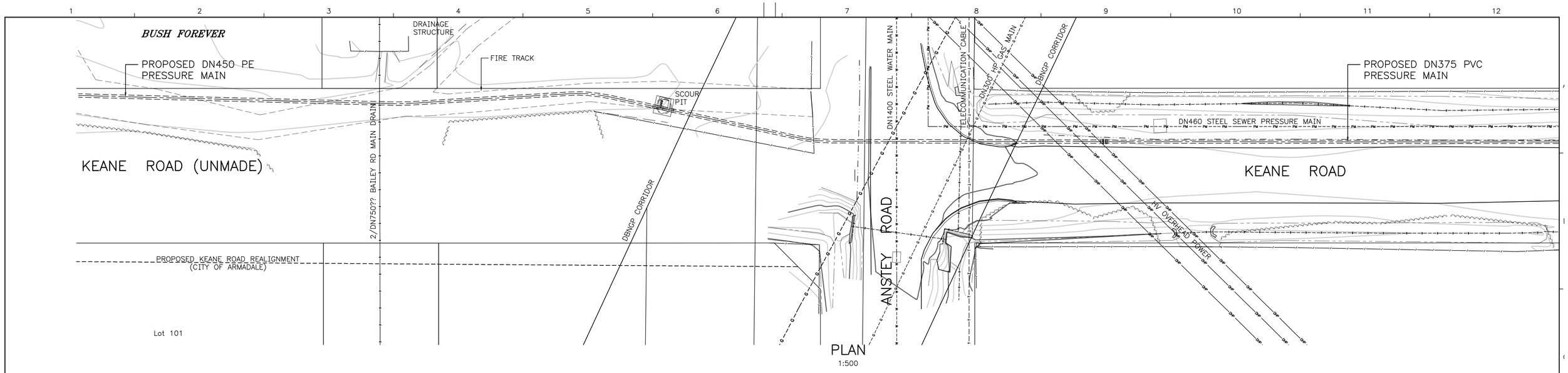
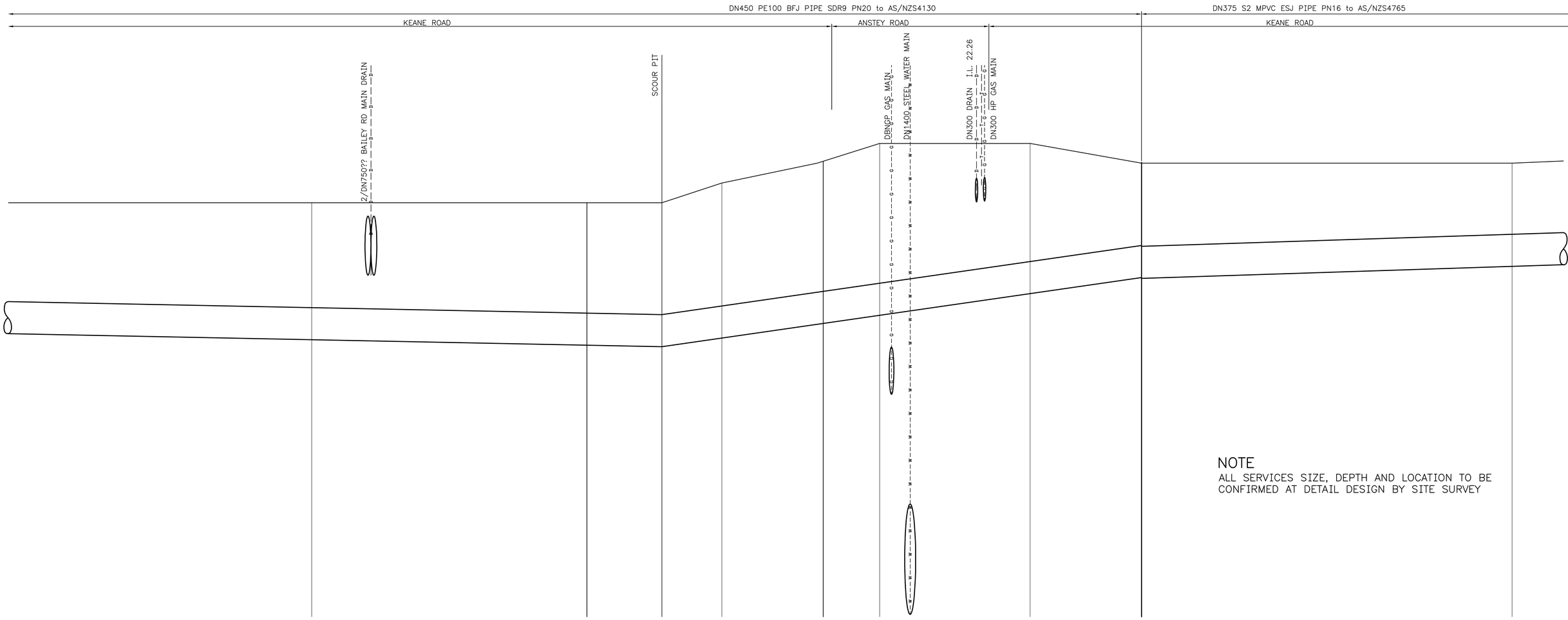
61\29471\CADD\HW91\HW91-085-002-10A 10/09/2013





NOTE
ALL SERVICES SIZE, DEPTH AND LOCATION TO BE CONFIRMED AT DETAIL DESIGN BY SITE SURVEY

SECTION
HORIZONTAL 1:250
VERTICAL 1:25

VERTICAL SCALE 500 0 500 1000 1500 mm (1:25)
HORIZONTAL SCALE 5 4 3 2 1 0 5 10 15 m (1:250)

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM AHD	DES CALC K.BOSMAN
	COORDINATE SYS MGA94-50	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
DBNGP CROSSING

FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C-S01249	HW91-85-2-11		A	A1 MF

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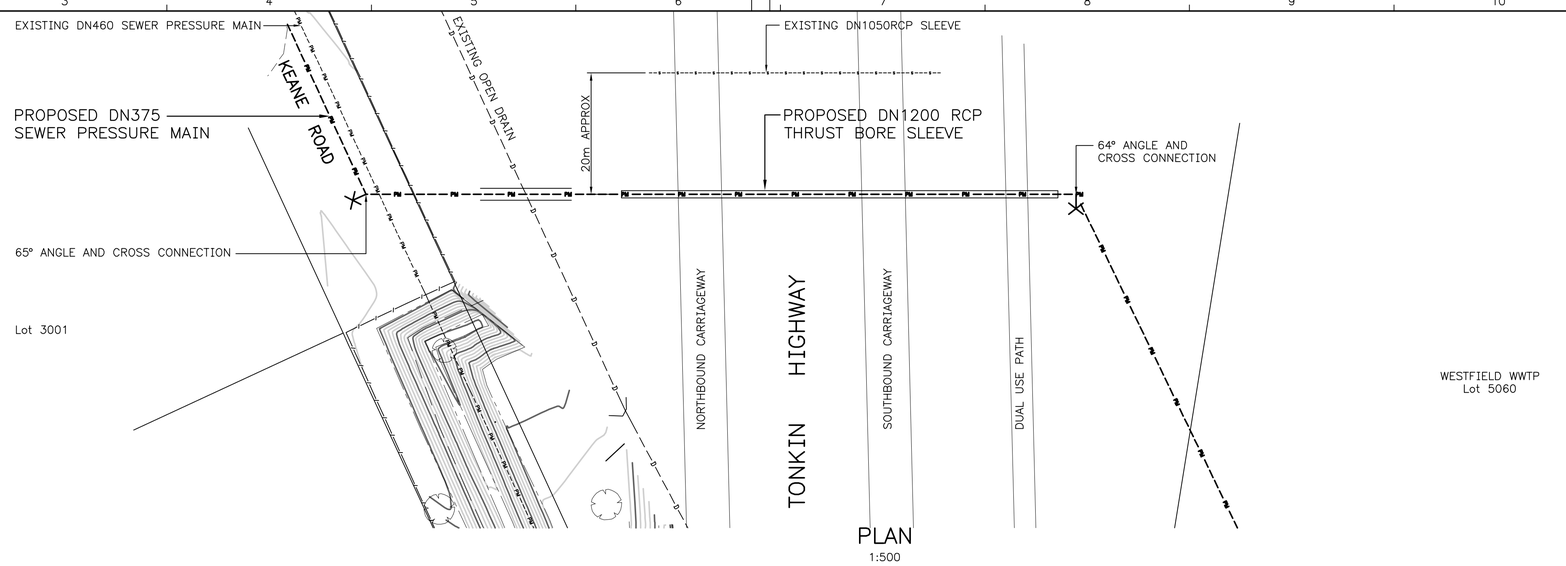
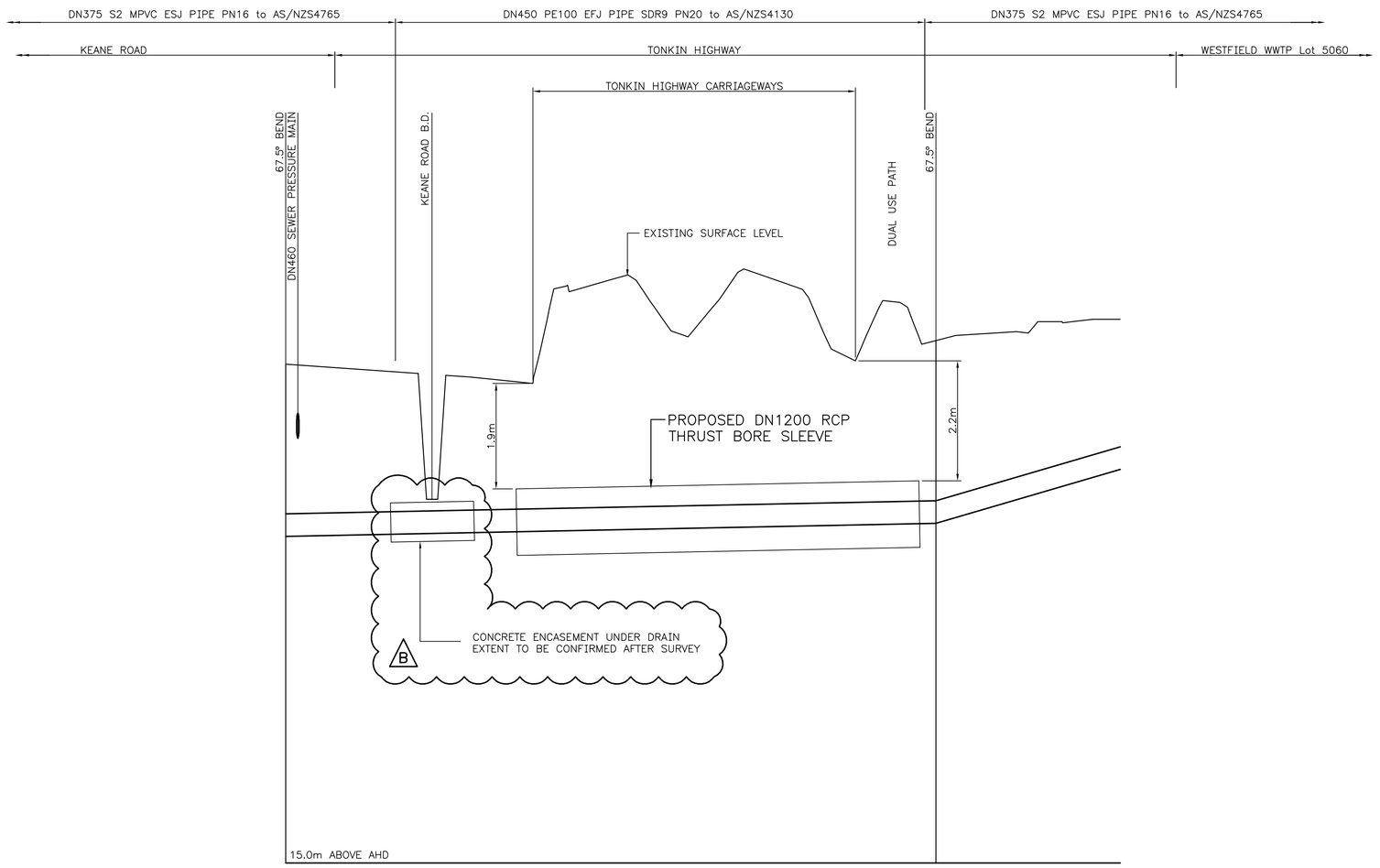


PLAN
1:500



SECTION
HORIZONTAL 1:500
VERTICAL 1:50

VERTICAL SCALE 1000 500 0 1000 2000 3000 mm (1:50)
HORIZONTAL SCALE 5 0 5 10 15 20 25 30 35 m (1:500)

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 6-Feb-2014

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	02/2014		CONCRETE ENCASEMENT ADDED TO DRAIN CROSSING	KB	KB	PGS

DESIGN SURVEY GHD 2661551 V01	VERTICAL DATUM NONE	DES CALC K.BOSMAN
	COORDINATE SYS NONE	DES CHD P.SPENCER
ASCON SURVEY NONE	DES REF GHD 61-29471	DRN K.BOSMAN
		Q.C. CHD R.SPILLANE

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CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 - COLLARED ST & PM
ENGINEERING DESIGN - DN375 PRESSURE MAIN
TONKIN HIGHWAY CROSSING

FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C-S01249	HW91-85-2-12		B	A1
			MF	

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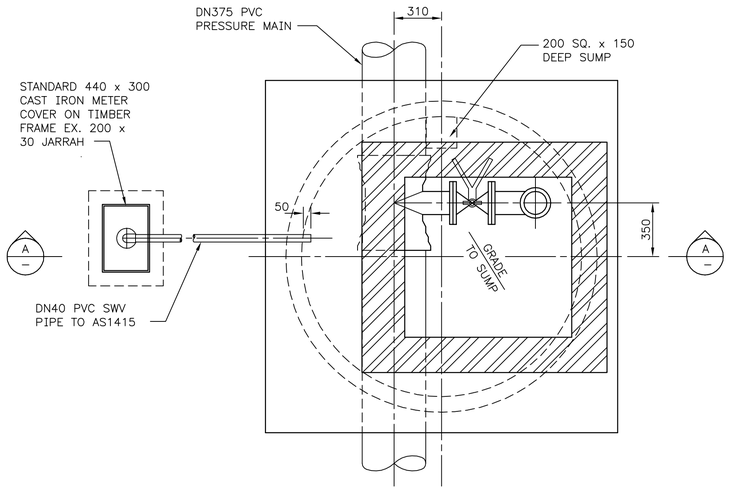
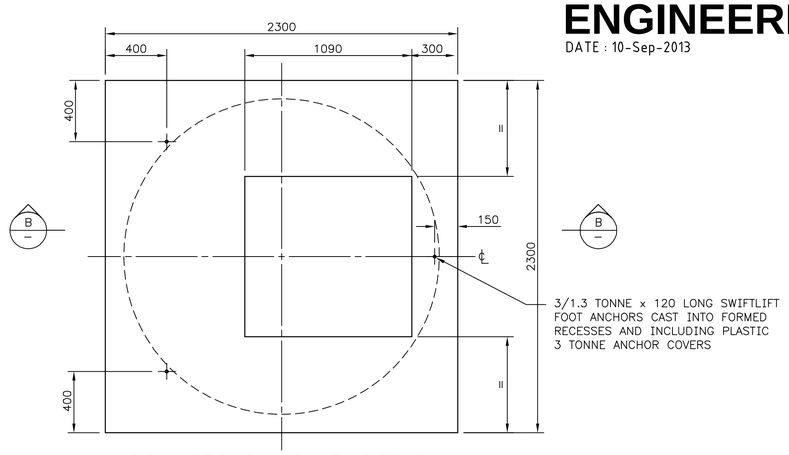
ENGINEERING DESIGN - NOT FOR CONSTRUCTION

DATE : 10-Sep-2013



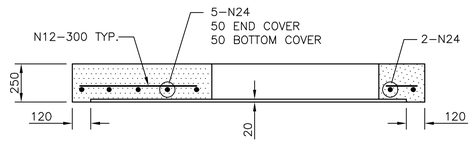
PLAN

SCALE (1)



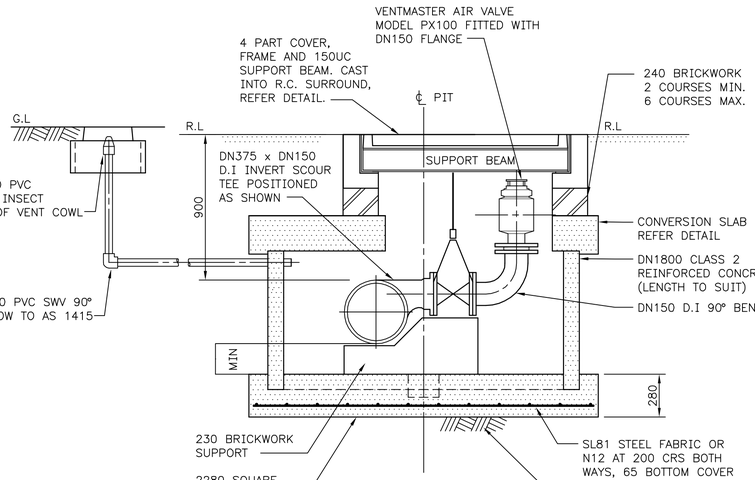
CONVERSION SLAB DETAIL

SCALE (1)



SECTION B

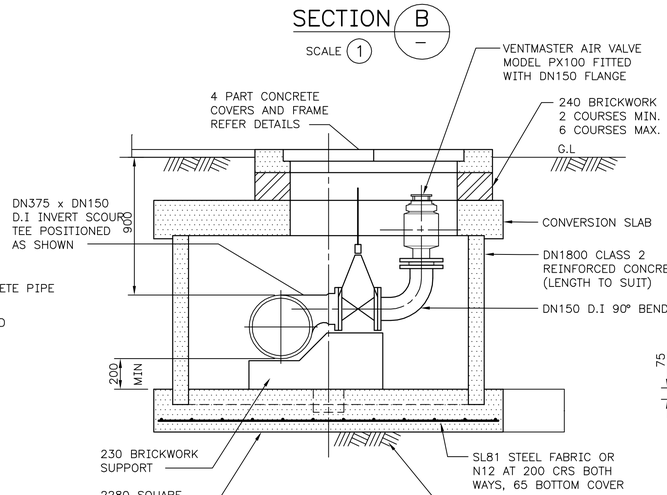
SCALE (1)



SECTION A

SCALE (1)

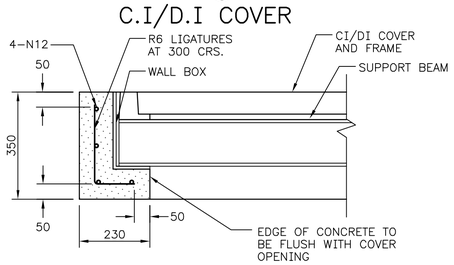
C.I/D.I COVER



SECTION A

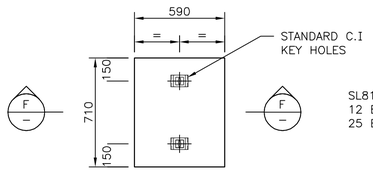
SCALE (1)

CONCRETE COVER



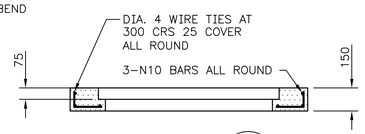
C.I/D.I COVER SURROUND DETAIL

SCALE (2)



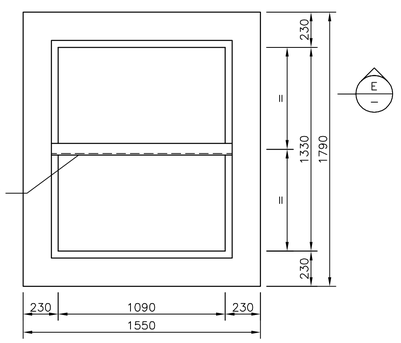
CONCRETE COVER DETAIL

SECTION F



SECTION E

SCALE (1)



FRAME DETAIL

GENERAL NOTES

1. ALL DIMENSION IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STEELWORK SHALL COMPLY WITH AS4100 AND SHALL BE HOT DIP GALVANISED AFTER FABRICATION TO AS/NZS4680. STEELWORK TO BE FABRICATED TO SUIT HOT–DIP GALVANISING REQUIREMENTS. INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
3. DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS4680 USING 'DIMET ZEDEN' OR ACCEPTABLE EQUIVALENT PRODUCT.
4. ALL WELDS TO BE 6mm CONTINUOUS FILLET WELDS TO AS1554 PT. 1.
5. CONCRETE SHALL BE GRADE N32 TO AS1379 PLACED IN ACCORDANCE WITH AS3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE GRADE 500N TO AS/NZS4671.
7. GATE VALVES SHALL BE TO SPS 272 AND RESILIENT SEATED. ALL FLANGES AND FLANGE DRILLING SHALL COMPLY WITH AS4087 PN16.
8. DUCTILE IRON PIPE FITTINGS SHALL BE TO AS2280 AND SHALL BE FUSION BONDED NYLON COATED INTERNALLY AND EXTERNALLY. SOCKETED (RRJ) D.I. PRESSURE MAIN FITTINGS SHALL MATCH THE AS/NZS1477 SERIES 2 PVC PIPE DIAMETER, EXCEPT WHERE OTHERWISE SHOWN.
9. ALL FASTENERS SHALL BE 12ø SS. SS TO BE TO ASTM A276 GRADE 316.
10. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
11. AIR VALVE AVAILABLE FROM GFR INDUSTRIES, 8 ARTELLO BAY RD, MIDVALE WA 6056 PHONE (08) 9250 2944. TO SPS 201.
12. UNLESS OTHERWISE SHOWN. ALL FLANGE BOLTS, NUTS AND WASHERS TO BE HOT DIP GALVANISED STEEL. ALL DAMAGE TO HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS4680 USING 'DIMET ZEDEN' OR APPROVED SIMILAR PRODUCT.
13. UNLESS SHOWN OTHERWISE METALLIC FLANGED JOINTWORK INCLUDING NUTS AND BOLTS SHALL BE FIELD–WRAPPED BY A PROTECTION SYSTEM COMPRISING 'DENSO 600' TAPE AND 'DENSO 901' OVERWRAP TAPE OR APPROVED EQUIVALENT.

REFERENCE DRAWINGS

PLAN AND LONGITUDINAL SECTIONS	85–2–1 TO 85–2–8

1 500 0 500 1000 mm (SCALE 1:20 – A1 DRAWING)

2 100 50 0 100 200 300 400 500 600 700 mm (SCALE 1:10 – A1 DRAWING)

THIS DRAWING IS DERIVED FROM CA01–52–3A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

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DESIGN SURVEY	VERTICAL DATUM NONE	DES CALC WC STD	NORTH POINT
	COORDINATE SYS NONE	DES CHD WC STD	
ASCON SURVEY NONE	DES REF GHD 61–29471	DRN K.BOSMAN	
		Q.C. CHD R.SPILLANE	

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CONSULTANT PROJECT DIRECTOR	

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
AIR VALVE ARRANGEMENT AND DETAILS

FILE	PLAN	CAD	ISSUE	ORIGINAL SHEET SIZE
PROJECT C–S01249	HW91–85–2–13		A	A1
			MF	

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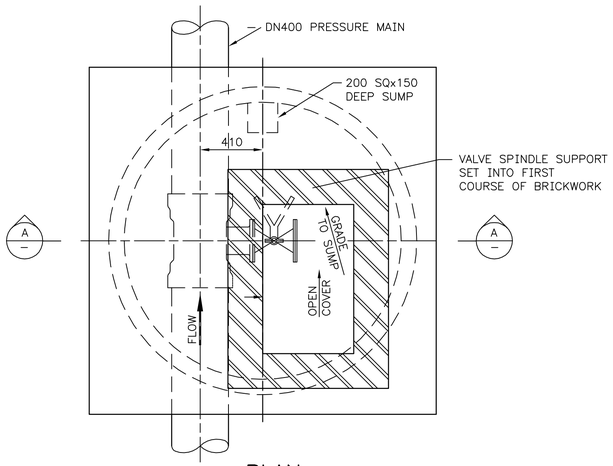
61\29471\CADD\HW91\HW91–085–002–13A 10/09/2013

ENGINEERING DESIGN - NOT FOR CONSTRUCTION

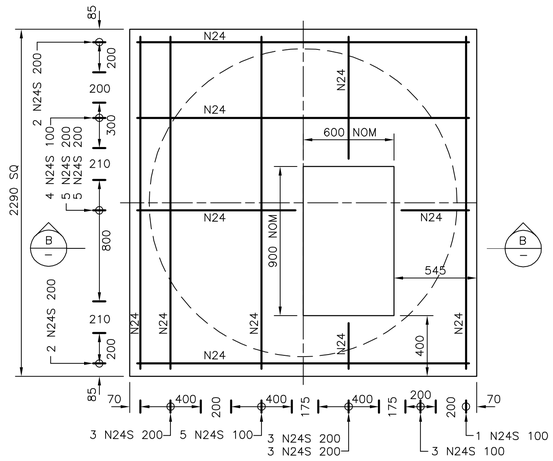
DATE : 6-Feb-2014



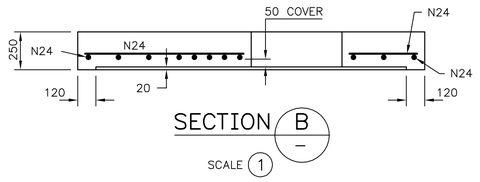
PLAN

SCALE (1)

C.I./D.I. CLASS D COVERS SHALL BE USED IN ROAD PAVEMENTS.
C.I./D.I. CLASS C COVERS SHALL BE USED IN ROW'S AND CARPARKS.
REINFORCED CONCRETE COVERS SHALL BE USED ELSEWHERE.

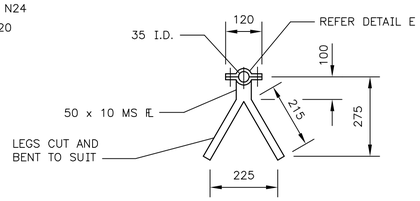


CONVERSION SLAB



SECTION (B)

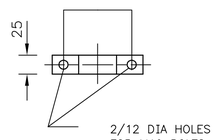
SCALE (1)



VALVE SPINDLE SUPPORT BRACKET

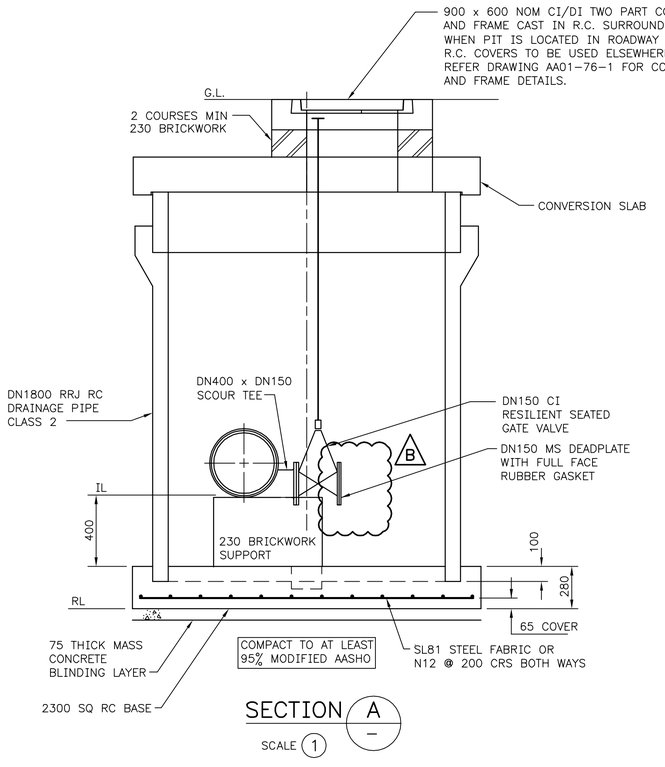
HOT DIP GALVANISED

SCALE : DIAGRAMMATIC



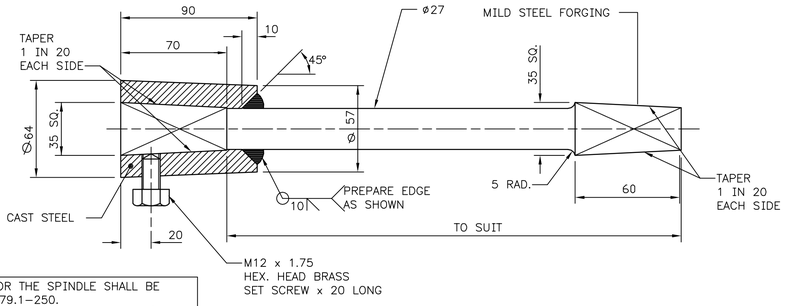
DETAIL (E)

SCALE (2)



SECTION (A)

SCALE (1)



- MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1-250.
- CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
- THE SPINDLE INCLUDING TAPERED KEY END SHALL COMPLY WITH AS 2638.2
- ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1

VALVE SPINDLE EXTENSION

SCALE : DIAGRAMMATIC

GENERAL NOTES

1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STRUCTURAL STEELWORK WELDING SHALL COMPLY WITH AS 1554 – PART 1. STEELWORK FABRICATION SHALL COMPLY WITH AS 4100.
3. MILD STEEL (MS) LADDER COMPONENTS SHALL BE HOT-DIP GALVANISED AFTER FABRICATION TO AS/NZS 4680. STEELWORK SHALL BE FABRICATED TO SUIT HOT-DIP GALVANIZING REQUIREMENTS, INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
4. ALL DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS 4680 USING 'DIMET ZEDEN' OR APPROVED EQUIVALENT PRODUCT.
5. CONCRETE SHALL BE GRADE N32 TO AS 1379 PLACED IN ACCORDANCE WITH AS 3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE IRON GRADE 500N TO AS/NZS 4671.
7. SLUICE VALVES SHALL BE RESILIENT SEATED AND TO SPS 272.
8. ALL FASTENERS SHALL BE STAINLESS STEEL TO ASTM A276 GRADE 316L.
9. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT BLINDING LAYER AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
10. EXTENSION SPINDLES TO CONFORM TO WATER CORPORATION STANDARD DRG AQ71-3-1 (LENGTH TO SUIT) AND FIXED WITH M12 SET SCREW TO VALVE SPINDLE. SPINDLES GREATER THAN 2m IN LENGTH SHALL REQUIRE AN ADDITIONAL MID-HEIGHT SUPPORT ATTACHED TO THE MANHOLE LINER.
11. MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1-250
12. CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
13. THE SPINDLE INCLUDING TAPERED KEY END SHALL BE HOT FORGED.
14. CAST STEEL SOCKET END AND TAPERED KEY END SHALL COMPLY WITH AS 2638.2
15. ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1
16. DEPTH TO TOP OF VALVE SPINDLE SHALL BE MEASURED OR CALCULATED FROM THE FINISHED SURFACE LEVEL

REFERENCE DRAWINGS

PLAN AND LONGITUDINAL SECTIONS 85-2-1 TO 85-2-8

(1) 500 0 500 1000 mm (SCALE 1:20 – A1 SHEET)

(2) 100 50 0 100 200 300 mm (SCALE 1:5 – A1 SHEET)

THIS DRAWING IS DERIVED FROM CA01-54-5A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD
B	11/2013	2G	ARROW RELOCATED TO POINT AT DEADPLATE	KB	GD	PGS

DESIGN SURVEY NONE | VERTICAL DATUM NONE | COORDINATE SYS NONE | DES CALC WC STD | DES CHD WC STD | ASCON SURVEY NONE | DES REF GHD 61-29471 | DRN K.BOSMAN | Q.C. CHD R.SPILLANE | NORTH POINT

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APPROVED 09/09/2013 P.G. SPENCER (SIGNED) CONSULTANT PROJECT DIRECTOR

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METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175-01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
GREATER THAN 2.2m TO INVERT – SCOUR ARRANGEMENT AND DETAILS

ORIGINAL SHEET SIZE A1

FILE JT1 201202141 VO1 | PLAN CAD HW91-85-2-14 | ISSUE B | PROJECT C-S01249 | MF

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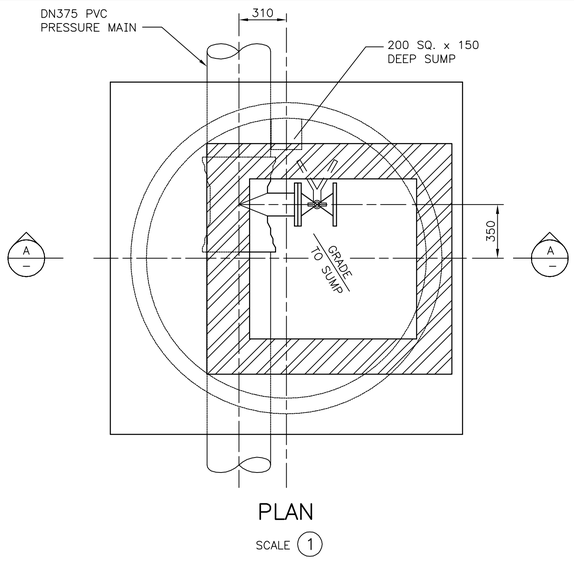
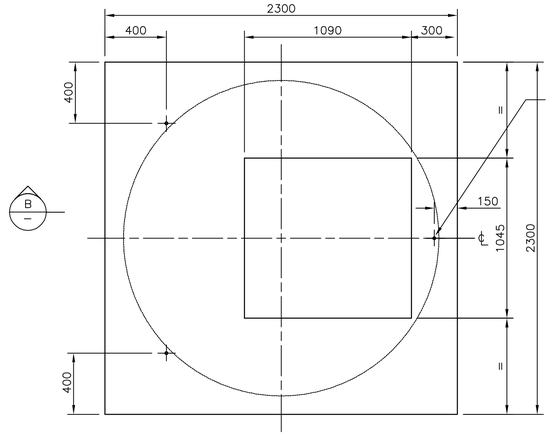


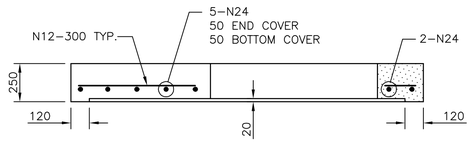
PLAN

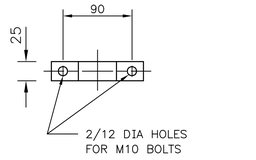
SCALE (1)



CONVERSION SLAB DETAIL

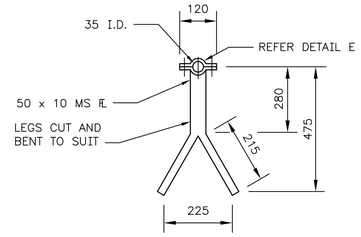
SCALE (1)





DETAIL (E)

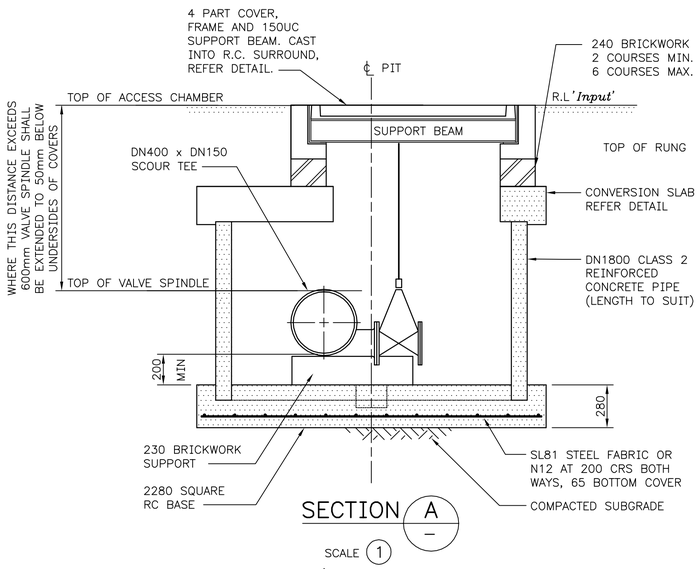
SCALE (3)



VALVE SPINDLE
SUPPORT BRACKET

HOT DIP GALVANISED

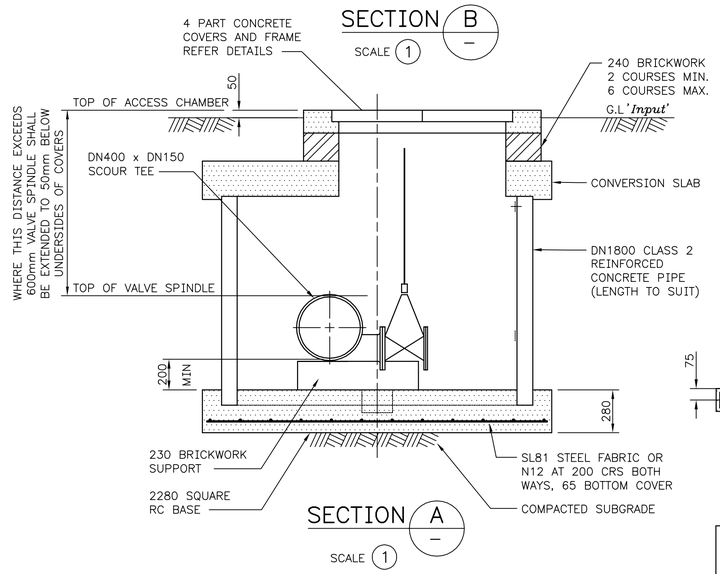
SCALE : DIAGRAMMATIC



SECTION (A)

SCALE (1)

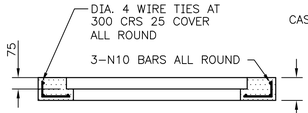
C.I/D.I COVER



SECTION (A)

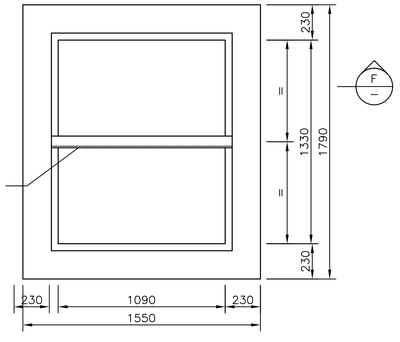
SCALE (1)

CONCRETE COVER

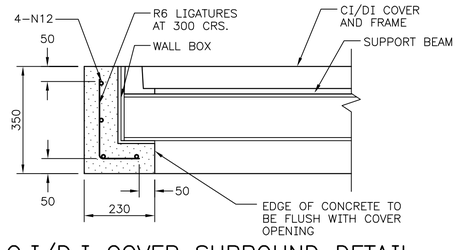


SECTION (F)

SCALE (1)

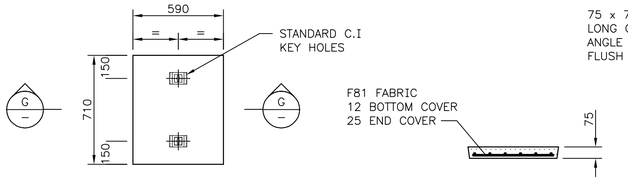


FRAME DETAIL



C.I/D.I COVER SURROUND DETAIL

SCALE (2)



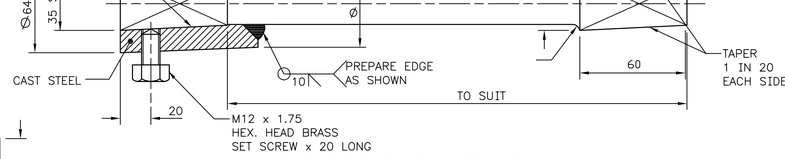
CONCRETE COVER DETAIL

SECTION (G)

(1) 500 0 500 1000 mm (SCALE 1:20 – A1 SHEET)

(2) 100 50 0 100 200 300 400 500 600 700 mm (SCALE 1:10 – A1 SHEET)

- MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1–250.
- CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
- THE SPINDLE INCLUDING TAPERED KEY END SHALL COMPLY WITH AS 2638.2
- ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1



VALVE SPINDLE EXTENSION

SCALE : DIAGRAMMATIC

GENERAL NOTES

1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS SHOWN OTHERWISE.
2. ALL STRUCTURAL STEELWORK WELDING SHALL COMPLY WITH AS 1554 – PART 1. STEELWORK FABRICATION SHALL COMPLY WITH AS 4100.
3. MILD STEEL (MS) LADDER COMPONENTS SHALL BE HOT–DIP GALVANISED AFTER FABRICATION TO AS/NZS 4680. STEELWORK SHALL BE FABRICATED TO SUIT HOT–DIP GALVANISING REQUIREMENTS, INCLUDING REMOVAL OF SHARP EDGES, WELDING SLAG AND SURFACE IRREGULARITIES.
4. ALL DAMAGE TO THE HOT DIP GALVANISING SHALL BE REPAIRED IN ACCORDANCE WITH APPENDIX E OF AS/NZS 4680 USING 'DIMET ZEDEN' OR APPROVED EQUIVALENT PRODUCT.
5. CONCRETE SHALL BE GRADE N32 TO AS 1379 PLACED IN ACCORDANCE WITH AS 3600.
6. REINFORCING STEEL TO BE NORMAL DUCTILE GRADE 500N TO AS/NZS 4671.
7. SLUICE VALVES SHALL BE RESILIENT SEATED AND TO SPS 272.
8. ALL FASTENERS SHALL BE STAINLESS STEEL TO ASTM A276 GRADE 316L.
9. IF SOIL AT VALVE PIT FOUNDATION LEVEL IS NOT SAND IT SHALL BE EXCAVATED TO A MIN. DEPTH OF 300mm BELOW PIT BLINDING LAYER AND THIS EXCAVATION REFILLED WITH SAND. FOUNDATION OR SAND REFILL MATERIAL SHALL BE COMPACTED AS PIPE UNDERLAY
10. EXTENSION SPINDLES TO CONFORM TO WATER CORPORATION STANDARD DRG AQ71–3–1 (LENGTH TO SUIT) AND FIXED WITH M12 SET SCREW TO VALVE SPINDLE. SPINDLES GREATER THAN 2m IN LENGTH SHALL REQUIRE AN ADDITIONAL MID–HEIGHT SUPPORT ATTACHED TO THE MANHOLE LINER.
11. MILD STEEL FOR THE SPINDLE SHALL BE TO AS/NZS 3679.1–250
12. CAST STEEL SHALL BE GRADE AS 2074/C3. CASTINGS TO BE SOUND AND FREE OF BURRS AND SHARP EDGES.
13. THE SPINDLE INCLUDING TAPERED KEY END SHALL BE HOT FORGED.
14. CAST STEEL SOCKET END AND TAPERED KEY END SHALL COMPLY WITH AS 2638.2
15. ALL WELDING WORK SHALL CONFORM TO AS/NZS 1554.1
16. DEPTH TO TOP OF VALVE SPINDLE SHALL BE MEASURED OR CALCULATED FROM THE FINISHED SURFACE LEVEL

REFERENCE DRAWINGS

PLAN AND LONGITUDINAL SECTIONS 85–2–1 TO 85–2–8

THIS DRAWING IS DERIVED FROM CA01–54–4A

ISSUE	DATE	GRID	REVISION	DRN	REC	APPD

DESIGN SURVEY | VERTICAL DATUM NONE | DES CALC WC STD | NORTH POINT

COORDINATE SYS NONE | DES CHD WC STD

ASCON SURVEY NONE | DES REF GHD 61–29471 | DRN K.BOSMAN

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RECOMMENDED 09/09/2013
G. DUNLOP (SIGNED)
CONSULTANT JOB MANAGER

APPROVED 09/09/2013
P.G. SPENCER (SIGNED)
CONSULTANT PROJECT DIRECTOR

WATER CORPORATION

METROPOLITAN WASTEWATER WAPC 127155
BALANNUP PUMPING STATION NO.175–01 – COLLARED ST & PM
ENGINEERING DESIGN – DN375 PRESSURE MAIN
LESS THAN 2.2m TO INVERT – SCOUR ARRANGEMENT AND DETAILS

ORIGINAL SHEET SIZE A1

FILE | PLAN HW91–85–2–15 | CAD | ISSUE A | MF

PROJECT C–S01249

566
810

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61\29471\CADD\HW91\HW91–085–002–15A 10/09/2013

Appendix C – Site Investigation Results

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					ASS - Potential Acidity		ASS - Net Acidity excl A		ASS - Excess ANC			ASS - Acid Base Accounting					
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANCFF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% Ca	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																						
BH01	0	25/06/2013	26.8	8.8	6.1	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	0.5	25/06/2013	26.3	8.6	6.2	**2.4**	2	9.6	**7.5**	**2.1**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	68	0.14	0.14	0.28	0.11	<5	<0.005	<0.005	0.008	0.006	-	-	<10	<0.02	178	0.89	0.28	1.5	<10	<1	<1	<0.02
BH01	1.5	25/06/2013	25.3	8.4	6.1	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	2	25/06/2013	24.8	8.6	6	**2.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	2.5	25/06/2013	24.3	8.1	5.9	**2.2**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH01	3	25/06/2013	23.8	8.4	6	**2.4**	1	9.1	**7**	**2.1**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.07	0.06	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	44	0.22	0.07	1.5	<10	<1	<1	<0.02
BH02	0	25/06/2013	26.5	8.3	6.4	1.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	0.5	25/06/2013	26	9.7	6.7	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	1	25/06/2013	25.5	8	5.1	**2.9**	2	7.4	**3.4**	**4**	<0.005	**0.41**	**0.41**	<2	**256**	**256**	10	<0.005	0.02	0.02	<5	<0.005	0.37	0.29	<0.005	<5	<0.005	0.02	0.02	<0.005	-	-	10	0.02	-	-	-	1.5	174	13	1	0.28
BH02	1.5	25/06/2013	25	7.8	6.1	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	2	25/06/2013	24.5	7.9	6.2	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	2.5	25/06/2013	24	7.4	6.2	1.2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH02	3	25/06/2013	23.5	8.2	6.1	**2.1**	2	8	**6.3**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	12	0.006	0.02	0.02	<5	<0.005	0.29	0.15	<0.005	<5	<0.005	0.008	0.006	<0.005	-	-	12	0.02	-	-	-	1.5	<10	<1	1	<0.02
BH03	0	25/06/2013	26.9	9.4	6.6	**2.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	0.5	25/06/2013	26.4	9.6	6.6	**3**	1	9.7	**8**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	2670	5.36	0.22	5.58	4.28	38	0.05	0.006	0.05	0.06	-	-	<10	<0.02	3560	17.8	5.71	1.5	<10	<1	<1	<0.02
BH03	1	25/06/2013	25.9	9.1	6.6	**2.5**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	1.5	25/06/2013	25.4	9.4	6.7	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	2	25/06/2013	24.9	9	6	**3**	2	8.7	**6.8**	1.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.09	0.08	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	22	0.11	0.04	1.5	<10	<1	<1	<0.02
BH03	2.5	25/06/2013	24.4	6.7	5.7	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH03	3	25/06/2013	23.9	7.2	5.6	1.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	0	25/06/2013	25.5	8.7	6.5	**2.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	0.5	25/06/2013	25	8.4	6.2	**2.2**	2	8.2	**9.3**	-1.1	<0.005	<0.005	<0.005	<2	<2	<2	**48**	0.009	0.08	**0.08**	242	0.48	0.43	0.91	0.39	8	0.009	0.01	0.02	0.01	-	-	**48**	**0.08**	379	1.9	0.61	1.5	<10	<1	4	<0.02
BH04	1.5	25/06/2013	24	8.4	6.2	**2.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	2	25/06/2013	23.5	8.3	6.2	**2.1**	2	9.2	**7.5**	1.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	0.01	<0.005	332	0.66	0.27	0.93	0.53	6	0.007	0.006	0.01	0.01	-	-	<10	<0.02	498	2.49	0.8	1.5	<10	<1	<1	<0.02
BH04	2.5	25/06/2013	23	8.2	5.9	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH04	3	25/06/2013	22.5	8.3	5.9	**2.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	0	27/06/2013	25.5	8.9	6.3	**2.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	0.5	27/06/2013	25	7.8	5.9	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	1	27/06/2013	24.5	7.4	5.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	1.5	27/06/2013	24	7.2	5.9	1.3	1	7	**5.5**	1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH05N	2	27/06/2013	23.5	7.3	5.6	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05N	2.5	27/06/2013	23	5	**3.5**	1.5	1	5.1	**2.6**	**2.5**	**0.1**	**0.78**	**0.68**	**63**	**485**	**422**	**62**	<0.005	**0.1**	**0.1**	<5	<0.005	0.08	0.08	<0.005	<5	<0.005	0.02	0.01	<0.005	<0.005	<5	**126**	**0.2**	-	-	-	1.5	126	9	9	0.2
BH05N	2.9	27/06/2013	22.6	5.2	**3.9**	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	0	25/06/2013	25.4	9.1	6.5	**2.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	0.5	25/06/2013	24.9	8.7	5.8	**2.9**	1	8.5	**6.6**	1.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.06	0.04	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	20	0.1	0.03	1.5	<10	<1	<1	<0.02
BH05S	1.5	25/06/2013	23.9	6.6	4.9	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	2	27/06/2013	23.4	4.4	5.5	-1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH05S	2.5	27/06/2013	22.9	5.3	4	1.3	1	4.8	**2.8**	2	**0.22**	**1.11**	**0.89**	**137**	**695**	**558**	**83**	<0.005	0.14	**0.13**	<5	<0.005	0.01	0.007	<0.005	<5	<0.005	0.008	0.007	<0.005	0.006	<5	**220**	**0.35**	-	-	-	1.5	220	17	17	0.35
BH06N	0.5	17/07/2013	22	8.9	7.4	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	1	17/07/2013	21.5	7.7	6.4	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	1.5	17/07/2013	21	8.2	6.9	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	2	17/07/2013	20.5	8.6	7.2	1.4	1	6.7	**7**	-0.3	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.08	<0.005	-	-	<10	<0.02	28	0.14	0.04	1.5	<10	<1	<1	<0.02
BH06N	2.5	17/07/2013	20	9.6	8.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	3	17/07/2013	19.5	9.4	7.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	3.5	17/07/2013	19	8.7	7.9	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	4	17/07/2013	18.5	9.3	8	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	4.5	17/07/2013	18	8.7	8	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	5	17/07/2013	17.5	9.2	7.5	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06N	5.5	17/07/2013	17	8.4	5.7	**2.7**	1	6.4	**4.4**	2	<0.005	**0.04**	**0.04**	<2	**23**	**23**	**57**	0.005	0.1	**0.09**	8	0.02	0.01	0.03	0.01	7	0.008	0.03	0.04	0.01	**0.038**	**24**	**57**	**0.09**	-	-	-	1.5	57	4	4	0.09
BH06N	6	17/07/2013	16.5	8.2	5.6	**2.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	0	27/06/2013	22.5	8.6	6.2	**2.4**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	0.5	27/06/2013	22	8.8	5.8	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	1	27/06/2013	21.5	9.3	6.2	**3.1**	1	5.9	**4.8**	1.1	0.02	<0.005	<0.005	10	<2	<2	<5	0.006	0.01	0.008	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.06	0.05	<0.005	<0.005	<5	15	0.02	-	-	-	1.5	15	1	1	0.02
BH06S	1.5	27/06/2013	21	8.2	5.4	**2.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	2	27/06/2013	20.5	8.6	6	**2.6**	1	6.8	**6.8**	0	<0.005	<0.005	<0.005	<2	<2	<2	**20**	0.01	0.05	0.03	16	0.03	0.03	0.06	0.02	<5	<0.005	0.05	0.05	0.005	-	-	**21**	0.03	24	0.12	0.04	1.5	<10	<1	2	<0.02
BH06S	2.5	27/06/2013	20	9.8	6.2	**3.6**	1	7.2	**6.7**	0.5	<0.005	<0.005	<0.005	<2	<2	<2	**38**	0.008	0.07	**0.06**	25	0.05	0.02	0.08	0.04	10	0.01	0.05	0.06	0.02	0.009	6	**38**	**0.06**	23	0.12	0.04	1.5	<10	<1	3	<0.02
BH06S	3	27/06/2013	19.5	9.1	6.3	**2.8**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	3.5	27/06/2013	19	8.6	4.3	**4.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	4	27/06/2013	18.5	9	**2.4**	**6.6**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	4.5	27/06/2013	18	8.8	**2.2**	**6.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	5	27/06/2013	17.5	8.7	**2.1**	**6.6**	2	6.7	**4.6**	**2.1**	<0.005	0.02	0.02	<2	16	16	**36**	0.01	0.07	**0.06**	<5	<0.005	0.02	0.02	<0.005	<5	<0.005	0.05	0.05	<0.005	**0.031**	**19**	**36**	**0.06**	-	-	-	1.5	23	2	3	0.04
BH06S	5.5	27/06/2013	17	8.9	**2.9**	**6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH06S	6	27/06/2013	16.5	9	**3.3**	**5.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	0.5	17/07/2013	23.25	6.9	6.3	0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	1	17/07/2013	22.75	5.2	4.7	0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	1.5	17/07/2013	22.25	5.4	4.8	0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	2	17/07/2013	21.75	5.4	5	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	2.5	17/07/2013	21.25	5.3	4.6	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH07	3	17/07/2013	20.75	5.4	4.6	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	0.5	17/07/2013	23.75	8.1	7.2	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	1	17/07/2013	23.25	7.5	6.7	0.8	1	6.9	**5.6**	1.3	<0.005	<0.005	<0.005	<2	<2	<2	**25**	<0.005	0.04	**0.04**	17	0.03	0.02	0.06	0.03	11	0.01	0.02	0.03	0.02	-	-	**25**	**0.04**	-	-	-	1.5	<10	1	2	<0.02
BH08	1.5	17/07/2013	22.75	6.9	6.7	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2	17/07/2013	22.25	5.8	5.6	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2.5	17/07/2013	21.75	5.6	5.3	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH08	2.8	17/07/2013	21.45	5.4	4.4	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					ASS - Potential Acidity		ASS - Net Acidity excl ANC		ASS - Excess ANC			ASS - Acid Base Accounting					
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANCFF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																							
BH09	0.5	17/07/2013	23.8	6.4	6.2	0.2	2	7	**4.4**	**2.6**	<0.005	<0.005	<0.005	<2	<2	<2	**31**	0.008	0.06	**0.05**	10	0.02	0.06	0.08	0.02	10	0.01	0.04	0.05	0.02	-	-	**31**	**0.05**	-	-	-	1.5	10	1	2	0.02
BH09	1	17/07/2013	23.3	6.3	6	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	1.5	17/07/2013	22.8	6.6	6.9	-0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	2	17/07/2013	22.3	5.5	5.2	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	2.5	17/07/2013	21.8	6	5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH09	3	17/07/2013	21.3	6	5.8	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	0.3	18/07/2013	23.1	7.2	7.1	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	1.5	18/07/2013	21.9	9.2	7.7	1.5	1	6.9	**7.1**	-0.2	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.07	0.06	<0.005	<5	<0.005	0.12	0.11	<0.005	-	-	<10	<0.02	37	0.18	0.06	1.5	<10	<1	<1	<0.02
BH10	2	18/07/2013	21.4	8.8	7.4	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	2.5	18/07/2013	20.9	8.6	7.3	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH10	3	18/07/2013	20.4	8	6.2	1.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	0.5	18/07/2013	23	9.5	7.9	1.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	1	18/07/2013	22.5	8.3	7.6	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	1.5	18/07/2013	22	9.6	8.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	2	18/07/2013	21.5	8.9	6.8	**2.1**	1	6.2	**7.7**	-1.5	<0.005	<0.005	<0.005	2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.19	0.15	<0.005	<5	<0.005	0.29	0.26	<0.005	-	-	<10	<0.02	61	0.31	0.1	1.5	<10	<1	<1	<0.02
BH11	2.5	18/07/2013	21	9.6	6.6	**3**	1	6.7	**6.7**	0	<0.005	<0.005	<0.005	<2	<2	<2	18	<0.005	0.03	0.03	9	0.02	0.04	0.06	0.01	<5	<0.005	0.06	0.06	<0.005	-	-	18	0.03	18	0.09	0.03	1.5	<10	<1	1	<0.02
BH11	3	18/07/2013	20.5	9.1	7.1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	3.5	18/07/2013	20	9.5	6.8	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	4	18/07/2013	19.5	9.3	6	**3.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH11	4.5	18/07/2013	19	9.2	**3.1**	**6.1**	1	6.4	**5.3**	1.1	<0.005	0.006	0.006	<2	4	4	16	<0.005	0.03	0.03	<5	<0.005	0.03	0.02	<0.005	<5	<0.005	0.04	0.03	<0.005	-	-	17	0.03	-	-	-	1.5	17	1	1	0.03
BH12	0.5	18/07/2013	23.25	8.8	6.9	1.9	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	1	18/07/2013	22.75	8.8	6.3	**2.5**	2	7.1	**6.2**	0.9	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH12	1.5	18/07/2013	22.25	7.3	5.9	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	2	18/07/2013	21.75	6.8	5.6	1.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	2.5	18/07/2013	21.25	4.5	**2**	**2.5**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	3	18/07/2013	20.75	5.8	**2.5**	**3.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	3.5	18/07/2013	20.25	6.2	**2.7**	**3.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12	4	18/07/2013	19.75	5.6	**1.6**	**4**	2	5.8	**3.4**	**2.4**	<0.005	**0.04**	**0.04**	2	**26**	**24**	**33**	0.006	0.06	**0.05**	<5	<0.005	0.01	0.01	<0.005	<5	<0.005	0.02	0.02	<0.005	-	-	**36**	**0.06**	-	-	-	1.5	36	3	3	0.06
BH12	4.5	18/07/2013	19.25	5.6	**1.5**	**4.1**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	0.5	19/07/2013	24.25	6.1	**3.7**	**2.4**	2	6.2	**3.5**	**2.7**	<0.005	<0.005	<0.005	<2	<2	<2	8	<0.005	0.01	0.01	<5	<0.005	0.06	0.04	<0.005	<5	<0.005	0.02	0.01	<0.005	-	-	<10	0.02	-	-	-	1.5	<10	1	1	0.02
BH13	1	19/07/2013	23.75	6.2	4.4	1.8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	1.5	19/07/2013	23.25	6.3	5	1.3	1	6.3	**5.2**	1.1	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH13	2	19/07/2013	22.75	6.3	4.9	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	2.5	19/07/2013	22.25	5.7	4.8	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	2.8	19/07/2013	21.95	5.9	5	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	3.5	19/07/2013	21.25	5.7	4.8	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH13	3.5	25/07/2013	21.25	-	-	-	-	5.7	**5.1**	0.6	0.01	**0.04**	0.03	8	**27**	**19**	<5	<0.005	0.008	0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	12	0.02	-	-	-	1.5	12	1	1	0.02
BH14	0.5	22/07/2013	24.4	**3.7**	4	-0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	1.5	22/07/2013	23.4	**3.9**	**3.2**	0.7	1	6.7	**4.5**	**2.2**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH14	2	22/07/2013	22.9	4.4	**3.3**	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	2.5	22/07/2013	22.4	4.2	4	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	3	22/07/2013	21.9	4.3	**3.8**	0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	3.3	22/07/2013	21.6	4.7	**3.8**	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	4.5	22/07/2013	20.4	4.6	**3.9**	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	5.5	22/07/2013	19.4	4.9	**3.8**	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH14	5.95	22/07/2013	18.95	5.2	4.4	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	0.5	23/07/2013	24.5	4.8	4.8	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	1	23/07/2013	24	4	4.6	-0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	1.5	23/07/2013	23.5	**3.9**	**3.6**	0.3	1	4.7	**2.4**	**2.3**	**0.2**	**0.84**	**0.64**	**123**	**521**	**398**	**51**	<0.005	0.08	**0.08**	<5	<0.005	0.005	0.005	<0.005	<5	<0.005	0.03	0.02	<0.005	-	-	**174**	**0.28**	-	-	-	1.5	174	13	13	0.28
BH15	2	23/07/2013	23	**3.6**	**3.2**	0.4	1	5.3	**4.2**	1.1	**0.09**	**0.2**	**0.11**	**55**	**125**	**70**	11	0.04	0.06	0.02	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	**66**	**0.11**	-	-	-	1.5	66	5	5	0.11
BH15	3.45	23/07/2013	21.55	4.8	4.4	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	4.5	23/07/2013	20.5	5.2	4.2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	4.95	23/07/2013	20.05	5.6	4.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	5.5	23/07/2013	19.5	5.6	4.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH15	5.95	23/07/2013	19.05	5.6	4.2	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	0.5	23/07/2013	23.9	5.2	5	0.2	1	6.8	**3.3**	**3.5**	<0.005	0.01	0.01	<2	8	8	<5	<0.005	<0.005	<0.005	<5	<0.005	0.006	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH16	1	23/07/2013	23.4	4.4	4.8	-0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	1.5	23/07/2013	22.9	4.6	4.5	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	2	23/07/2013	22.4	**3.8**	**3.5**	0.3	1	5.2	**3.9**	1.3	**0.08**	**0.32**	**0.23**	**52**	**197**	**145**	**25**	<0.005	0.04	**0.04**	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	0.014	9	**77**	**0.12**	-	-	-	1.5	77	6	6	0.12
BH16	3	23/07/2013	21.4	4.7	4.4	0.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4	23/07/2013	20.4	5.6	4.8	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.4	23/07/2013	20	5.5	4.5	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.5	23/07/2013	19.9	5.3	5.5	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH16	4.95	23/07/2013	19.45	5.4	4	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	3	25/07/2013	21.5	6.4	5.3	1.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	3.5	25/07/2013	21	7	4.7	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	4	25/07/2013	20.5	7.6	4.9	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	4.5	25/07/2013	20	7.8	4.8	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	5	25/07/2013	19.5	7.3	4.4	**2.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	5.5	25/07/2013	19	6.9	**2.1**	**4.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH17	6	25/07/2013	18.5	7.1	**3.3**	**3.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					ASS - Potential Acidity		ASS - Net Acidity excl ANC		ASS - Excess ANC			ASS - Acid Base Accounting					
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANCFF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																							
BH18	0.5	25/07/2013	23.5	4.5	5.7	-1.2	1	6	**4.1**	1.9	<0.005	**0.05**	**0.05**	<2	**30**	**29**	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH18	1	25/07/2013	23	4.9	5.7	-0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	1.5	25/07/2013	22.5	5.5	**3**	**2.5**	2	6.7	**3.3**	**3.4**	<0.005	0.03	0.03	<2	17	17	<5	<0.005	0.006	0.006	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	-	-	-	1.5	12	1	<1	0.02
BH18	2	25/07/2013	22	5.4	5.3	0.1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	2.5	25/07/2013	21.5	5.4	**2.1**	**3.3**	2	5.7	**3.3**	**2.4**	0.02	**0.08**	**0.07**	11	**53**	**42**	**30**	0.006	0.05	**0.05**	<5	<0.005	0.01	<0.005	<0.005	<5	<0.005	0.04	0.03	<0.005	0.018	11	**41**	**0.07**	-	-	-	1.5	41	3	3	0.07
BH18	3	25/07/2013	21	6.3	**2.3**	**4**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	3.5	25/07/2013	20.5	6.1	**2.4**	**3.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	4	25/07/2013	20	5.8	**3.1**	**2.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	4.5	25/07/2013	19.5	5.8	4.5	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	5	25/07/2013	19	7	**2.4**	**4.6**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	5.5	25/07/2013	18.5	6.7	**2**	**4.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH18	6	25/07/2013	18	6.8	**2.5**	**4.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	0.5	25/07/2013	23.4	5.7	5.9	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	1	25/07/2013	22.9	9	6.2	**2.8**	1	6.3	**6.8**	-0.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	0.02	0.02	<0.005	<5	<0.005	0.11	0.08	<0.005	<0.005	<5	<10	<0.02	16	0.08	0.02	1.5	<10	<1	<1	<0.02
BH19	1.5	25/07/2013	22.4	9.1	6.2	**2.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	2	25/07/2013	21.9	10.3	6	**4.3**	1	6.6	**6.4**	0.2	<0.005	<0.005	<0.005	<2	<2	<2	15	<0.005	0.02	0.02	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.07	<0.005	0.008	<5	15	0.02	-	-	-	1.5	<10	<1	1	<0.02
BH19	3	25/07/2013	20.9	10.1	6.4	**3.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	3.5	25/07/2013	20.4	10.2	6.2	**4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	4	25/07/2013	19.9	10.2	6.3	**3.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	4.5	25/07/2013	19.4	9.4	**3**	**6.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	5	25/07/2013	18.9	9.4	**2.4**	**7**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	5.5	25/07/2013	18.4	9.4	**2.8**	**6.6**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH19	6	25/07/2013	17.9	10	6.3	**3.7**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	0.5	25/07/2013	23.1	6.5	5.8	0.7	1	6.9	**4.4**	**2.5**	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	<1	<1	<0.02
BH20	1	25/07/2013	22.6	6.2	5.8	0.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	1.5	25/07/2013	22.1	6.8	5.9	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	2	25/07/2013	21.6	6.1	5.9	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	2.5	25/07/2013	21.1	8.1	6	**2.1**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	3	25/07/2013	20.6	9.4	6.4	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	3.5	25/07/2013	20.1	9.6	6.4	**3.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	4	25/07/2013	19.6	9.5	6.5	**3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	4.5	25/07/2013	19.1	8.9	6.4	**2.5**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	5	25/07/2013	18.6	9.1	6.1	**3**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	5.5	25/07/2013	18.1	8.7	**2.2**	**6.5**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH20	6	25/07/2013	17.6	8.7	6	**2.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	0.5	25/07/2013	23.25	6.1	5.9	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	1	25/07/2013	22.75	6.3	5.4	0.9	1	5.7	**3.1**	**2.6**	0.03	**0.39**	**0.36**	**20**	**242**	**223**	**68**	<0.005	0.11	**0.11**	<5	0.005	0.02	0.02	<0.005	<5	<0.005	0.06	0.05	<0.005	-	-	**87**	**0.14**	-	-	-	1.5	87	7	7	0.14
BH21	1.5	25/07/2013	22.25	6.5	4.8	1.7	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	2	25/07/2013	21.75	7.2	4.3	**2.9**	3	5.7	**2.8**	**2.9**	0.02	**0.26**	**0.25**	11	**164**	**153**	**78**	<0.005	0.13	**0.12**	<5	0.008	0.02	0.03	0.006	<5	<0.005	0.06	0.06	<0.005	<0.005	<5	**89**	**0.14**	-	-	-	1.5	89	7	7	0.14
BH21	2.5	25/07/2013	21.25	4.3	**2.1**	**2.2**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	3	25/07/2013	20.75	6.8	**2.9**	**3.9**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	3.5	25/07/2013	20.25	7.6	**3.2**	**4.4**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	4	25/07/2013	19.75	7.8	5.8	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	4.5	25/07/2013	19.25	7.6	5	**2.6**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	5	25/07/2013	18.75	7.4	**3.8**	**3.6**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	5.5	25/07/2013	18.25	7.5	**1.6**	**5.9**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH21	6	25/07/2013	17.75	7.3	**1.8**	**5.5**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	0.5	26/07/2013	23.3	5.6	5.8	-0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	1	26/07/2013	22.8	5.1	5.7	-0.6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	1.5	26/07/2013	22.3	6.6	5.7	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	2	26/07/2013	21.8	4.5	**3.8**	0.7	1	5.2	**2.5**	**2.7**	**0.08**	**0.47**	**0.39**	**48**	**293**	**245**	**46**	<0.005	0.08	**0.07**	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	0.01	0.01	<0.005	0.006	<5	**94**	**0.15**	-	-	-	1.5	94	7	7	0.15
BH22	2.5	26/07/2013	21.3	5.7	4.4	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	3	26/07/2013	20.8	5.5	4.6	0.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	3.5	26/07/2013	20.3	6.6	4.6	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	4	26/07/2013	19.8	6.8	4.4	**2.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	4.5	26/07/2013	19.3	6.6	**1.7**	**4.9**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	5	26/07/2013	18.8	6.6	**3.9**	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	5.5	26/07/2013	18.3	6.4	**2.6**	**3.8**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH22	6	26/07/2013	17.8	6.7	**1.7**	**5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	0.5	26/07/2013	22.9	5.6	5.6	0	1	6.6	**3.5**	**3.1**	<0.005	0.02	0.02	<2	14	14	11	<0.005	0.02	0.02	<5	<0.005	<0.005	0.008	<0.005	<5	<0.005	0.006	0.008	<0.005	-	-	11	0.02	-	-	-	1.5	13	1	1	0.02
BH23	1	26/07/2013	22.4	6	6.5	-0.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	1.5	26/07/2013	21.9	5.3	**3.8**	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	2	26/07/2013	21.4	5.4	5.2	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	2.5	26/07/2013	20.9	5.3	5.1	0.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	3	26/07/2013	20.4	5.8	**2.3**	**3.5**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	3.5	26/07/2013	19.9	6	**2.3**	**3.7**	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	4	26/07/2013	19.4	7.5	4.3	**3.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	4.5	26/07/2013	18.9	6.8	**2.5**	**4.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	5	26/07/2013	18.4	6.6	**2.2**	**4.4**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	5.5	26/07/2013	17.9	7.2	**2.6**	**4.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH23	6	26/07/2013	17.4	7.1	**2.9**	**4.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

				ASS - Field				ASS - pH			ASS - Acidity Trail						ASS - Sulfur Trail				ASS - Calcium Values					ASS - Magnesium Values					ASS - Potential Acidity		ASS - Net Acidity excl A		ASS - Excess ANC			ASS - Acid Base Accounting					
				pHF	pHFox	pH Difference (Field) - Calc	Reaction Rate	pH KCL	pHOX	pH Difference - Calc	s-TAA	s-TPA	s-TSA	Titratable Actual Acidity	TPA	TSA	a-SPOS	SKCl	SP	SPOS	a-CaA	CaA	CaKCL	CaP	sCaA	a-MgA	MgA	MgKCL	MgP	s-MgA	SCr (Sulfur Units)	SCr (Acidity Units)	Net Acidity excluding ANC (acidity units)	Net Acidity excluding ANC (sulfur units)	a-ANCE	ANCE	s-ANCE	ANCFF	a-NetAcidity	Liming Rate	Liming Rate excluding ANC	s-NetAcidity
				pH Units	pH Units	pH Units	-	pH Units	pH Units	pH Units	% pyrite S	% pyrite S	% pyrite S	mole H+/t	mole H+/t	mole H+/t	mole H+/t	% S	% S	% S	mole H+/t	% Ca	% Ca	% Ca	% S	mole H+/t	% Mg	% Mg	% Mg	% S	% S	mole H+/t	mole H+/t	% S	mole H+/t	% CaCO3	% S	-	mole H+/t	kg CaCO3/t	kg CaCO3/t	% S
EQL				0.1	0.1		1	0.1	0.1		0.005	0.005	0.005	2	2	2	5	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	5	0.005	0.005	0.005	0.005	0.005	5	10	0.02	10	0.02	0.02	0.5	10	1	1	0.02
DEC 2013 ASS Criteria				**<4**	**<4**	**2**			**<4**	**2**	**0.03**	**0.03**	**0.03**	**18.7**	**18.7**	**18.7**	**18.7**			**0.03**											**0.03**	**18.7**	**18.7**	**0.03**								
LocCode	**Sample Depth**	**Sampled Date**	**Sample Elevation**																																							
BH24	0.5	26/07/2013	22.4	8.8	6.3	**2.5**	2	6.2	**6.1**	0.1	<0.005	<0.005	<0.005	<2	<2	<2	7	0.006	0.02	0.01	<5	<0.005	0.03	0.03	<0.005	<5	<0.005	0.14	0.15	<0.005	-	-	<10	<0.02	-	-	-	1.5	<10	1	1	<0.02
BH24	1.5	26/07/2013	21.4	8.1	5.8	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	2	26/07/2013	20.9	8.8	**2.8**	**6**	4	6.2	**4.7**	1.5	<0.005	<0.005	<0.005	<2	<2	<2	**21**	<0.005	0.04	0.03	<5	<0.005	0.02	0.01	<0.005	<5	<0.005	0.07	0.06	<0.005	0.017	11	**22**	**0.04**	-	-	-	1.5	22	2	2	0.04
BH24	2.5	26/07/2013	20.4	7.9	4.6	**3.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	3	26/07/2013	19.9	7.8	4.3	**3.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	3.5	26/07/2013	19.4	8	4.5	**3.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	4	26/07/2013	18.9	8.3	**3.6**	**4.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	4.5	26/07/2013	18.4	7.6	**2.2**	**5.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	5	26/07/2013	17.9	8.2	**2.4**	**5.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	5.5	26/07/2013	17.4	8.2	**2.4**	**5.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH24	6	26/07/2013	16.9	7.3	**3.7**	**3.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	0.5	26/07/2013	22.25	8.8	6.9	1.9	3	6.7	**7.4**	-0.7	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.005	<0.005	<0.005	<5	<0.005	0.03	<0.005	<0.005	<5	<0.005	0.14	<0.005	<0.005	-	-	<10	<0.02	47	0.24	0.08	1.5	<10	<1	<1	<0.02
BH25	1	26/07/2013	21.75	8.4	6.1	**2.3**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	1.5	26/07/2013	21.25	7.9	6.1	1.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	2	26/07/2013	20.75	9.3	6.8	**2.5**	1	7	**7**	0	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.007	0.007	<0.005	<5	<0.005	0.03	0.03	<0.005	41	0.05	0.11	0.16	0.07	-	-	<10	<0.02	48	0.24	0.08	1.5	<10	<1	<1	<0.02
BH25	2.5	26/07/2013	20.25	9.4	6.8	**2.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	3	26/07/2013	19.75	9.2	6.3	**2.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	3.5	26/07/2013	19.25	9.2	**2.9**	**6.3**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	4	26/07/2013	18.75	8.8	**3.2**	**5.6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	4.5	26/07/2013	18.25	8.6	4.4	**4.2**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	5	26/07/2013	17.75	8.9	**3.9**	**5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	5.5	26/07/2013	17.25	8.1	4	**4.1**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH25	6	26/07/2013	16.75	8.6	**2.6**	**6**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	0.5	26/07/2013	21.8	9.7	6.9	**2.8**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	1	26/07/2013	21.3	9.3	6.4	**2.9**	2	9.3	**7.8**	1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.02	0.02	<0.005	159	0.32	0.16	0.48	0.25	36	0.04	0.06	0.1	0.06	-	-	<10	<0.02	274	1.37	0.44	1.5	<10	<1	<1	<0.02
BH26	1.5	26/07/2013	20.8	8.5	6.1	**2.4**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	2	26/07/2013	20.3	8.1	6	**2.1**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	2.5	26/07/2013	19.8	7.4	5.9	1.5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	3	26/07/2013	19.3	8.1	**1.6**	**6.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	3.5	26/07/2013	18.8	8.2	**1.7**	**6.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	4	26/07/2013	18.3	9.3	5.8	**3.5**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	4.5	26/07/2013	17.8	9	6.1	**2.9**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	5	26/07/2013	17.3	7.8	5.9	1.9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	5.5	26/07/2013	16.8	9	5.9	**3.1**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH26	6	26/07/2013	16.3	8	6.3	1.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	0.5	27/07/2013	21.8	8.7	6.3	**2.4**	1	7.7	**7.1**	0.6	<0.005	<0.005	<0.005	<2	<2	<2	<5	0.006	0.007	<0.005	<5	<0.005	0.03	0.02	<0.005	31	0.04	0.1	0.14	0.05	-	-	<10	<0.02	64	0.32	0.1	1.5	<10	<1	<1	<0.02
BH27	1	27/07/2013	21.3	8.4	6.2	**2.2**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	1.5	27/07/2013	20.8	8.3	6.1	**2.2**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	2	27/07/2013	20.3	7.4	6	1.4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	2.5	27/07/2013	19.8	9	6.3	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	3	27/07/2013	19.3	8.2	5.7	**2.5**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	3.5	27/07/2013	18.8	8.8	**2**	**6.8**	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	4	27/07/2013	18.3	9.3	**2.3**	**7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	4.5	27/07/2013	17.8	9	5.3	**3.7**	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	5	27/07/2013	17.3	9.1	5.7	**3.4**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH27	5.5	27/07/2013	16.8	8.8	6.1	**2.7**	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	0.5	18/07/2013	22.8	8.8	7.6	1.2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	1	18/07/2013	22.3	9.5	8.1	1.4	1	8.4	**7.5**	0.9	<0.005	<0.005	<0.005	<2	<2	<2	**30**	0.01	0.06	**0.05**	21	0.04	0.07	0.12	0.03	48	0.06	0.1	0.16	0.08	-	-	**30**	**0.05**	105	0.53	0.17	1.5	<10	<1	2	<0.02
BH28	1.5	18/07/2013	21.8	9	8.3	0.7	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	2	18/07/2013	21.3	8.4	**3.4**	**5**	1	7.9	**5.5**	**2.4**	<0.005	<0.005	<0.005	<2	2	2	**78**	0.03	0.16	**0.12**	16	0.03	0.08	0.11	0.03	13	0.02	0.11	0.12	0.02	**0.067**	**42**	**78**	**0.12**	-	-	-	1.5	28	2	6	0.04
BH28	2.5	18/07/2013	20.8	9.2	7.9	1.3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BH28	3	18/07/2013	20.3	8.4	7.6	0.8	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Statistical Summary

Number of Results	268	268	268	268	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	52	16	16	52	52	19	19	19	52	52	52	52	52	52
Number of Detects	268	268	268	268	52	52	52	11	19	19	13	20	20	28	19	35	31	13	15	42	40	14	12	12	37	37	14	10	7	28	29	19	19	19	52	21	24	30	22
Minimum Concentration	3.6	1.5	-1.2	1	4.7	2.4	-1.5	<0.005	<0.005	<0.005	<2	<2	<2	<5	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<5	<0.005	<0.005	<0.005	<0.005	<0.005	<5	<10	<0.02	16	0.08	0.02	1.5	<10	<1	<1	<0.02
Minimum Detect	3.6	1.5	ND	1	4.7	2.4	ND	0.01	0.006	0.006	2	2	2	7	0.005	0.006	0.005	8	0.005	0.005	0.005	0.006	6	0.007	0.006	0.006	0.005	0.006	6	10	0.02	16	0.08	0.02	1.5	10	1	1	0.02
Maximum Concentration	10.3	8.7	7	4	9.7	9.3	4	0.22	1.11	0.89	137	695	558	83	0.04	0.16	0.13	2670	5.36	0.43	5.58	4.28	48	0.06	0.29	0.26	0.08	0.067	42	220	0.35	3560	17.8	5.71	1.5	220	17	17	0.35
Maximum Detect	10.3	8.7	7	4	9.7	9.3	4	0.22	1.11	0.89	137	695	558	83	0.04	0.16	0.13	2670	5.36	0.43	5.58	4.28	48	0.06	0.29	0.26	0.08	0.067	42	220	0.35	3560	17.8	5.71	1.5	220	17	17	0.35
Average Concentration	7.4	5.1	2.3	1.4	6.8	5.4	1.5	0.019	0.1	0.084	11	62	52	20	0.0055	0.036	0.031	71	0.14	0.062	0.19	0.11	6.9	0.008	0.043	0.044	0.01	0.014	9	31	0.051	287	1.4	0.46	1.5	30	2.4	2.5	0.049
Median Concentration	7.8	5.6	2.2	1	6.7	5.4	1.7	0.0025	0.0025	0.0025	1	1	1	9	0.0025	0.02	0.015	2.5	0.0025	0.02	0.02	0.0025	2.5	0.0025	0.02	0.02	0.0025	0.007	2.5	11.5	0.02	47	0.24	0.08	1.5	5	0.5	1	0.01
Standard Deviation	1.6	1.7	1.8	0.71	1.2	1.8	1.2	0.045	0.23	0.19	28	146	120	23	0.0068	0.041	0.037	372	0.75	0.095	0.78	0.6	11	0.014	0.053	0.054	0.019	0.018	11	45	0.07	804	4	1.3	0	49	3.7	3.3	0.078
Number of Guideline Exceedances	0	0	143	0	0	0	19	6	14	13	7	14	14	19	0	0	17	0	0	0	0	0	0	0	0	0	0	3	3	20	19	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	143	0	0	0	19	6	14	13	7	14	14	19	0	0	17	0	0	0	0	0	0	0	0	0	0	3	3	20	19	0	0	0	0	0	0	0	0

Reaction Rate

1	Slight
2	Moderate
3	Strong
4	Extreme

Table 2, Appendix C
Acid Sulfate Soil Investigation Results
Keane Road Pressure Main, Balannup
Acid Sulfate Soil and Dewatering Management Plan

			Inorganics				Nutrients						Major Ions						Acidity	Alkalinity				Metals															
			Electrical conductivity *(lab)	pH (Lab)	Sulphide	Total Dissolved Solids	Ammonia as N	Kjeldahl Nitrogen Total	Nitrogen (Total Oxidised)	Nitrogen (Total)	Phosphorus	Reactive Phosphorus as P	Calcium (Filtered)	Chloride	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Sulphate (Filtered)	Acidity as CaCO3	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide) as CaCO3	Alkalinity (total) as CaCO3	Carbonate Alkalinity as CaCO3	Aluminium	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (III+VI) (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Iron	Iron (Filtered)	Lead (Filtered)	Manganese (Filtered)	Nickel (Filtered)	Selenium (Filtered)	Zinc (Filtered)
			uS/cm	pH Units	mg/L	mg/L	µg/L	mg/L	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			1	0.01	0.1	10	10	0.1	0.01	100	0.01	0.01	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01	0.001	0.0001	0.001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.01	0.005
ANZECC 2000 Freshwater							**2632**																	**0.027**	**0.027**		**0.00006**	**0.00001**		**0.001**			**0.001**	**1.2**	**0.008**	**0.005**	**0.0024**
ANZECC 2000 Short-term Irrigation										***25000***														***20***	***20***	***2***	***0.05***	***1***	***0.1***	***5***	***10***	***10***	***10***	***10***	***2***	***0.05***	***5***
Field ID	**Date**	**Lab Report Number**																																				
BH01	12/08/2013	EP1306149	531	7.43	0.2	398	50	1.2	6.52	7700	<0.05	0.01	84	30	11	6	29	55	22	199	<1	199	<1	**0.51**	**0.08**	<0.001	<0.0001	<0.001	<0.001	**0.002**	0.6	0.08	**0.002**	0.015	<0.001	<0.01	<0.005
BH03	12/08/2013	EP1306149	652	6.09	<0.1	570	880	4.8	12.2	17,000	0.33	0.25	58	80	14	18	51	104	113	100	<1	100	<1	**1.42**	**0.35**	0.001	<0.0001	<0.001	0.001	<0.001	1.01	0.6	<0.001	0.086	0.001	<0.01	**0.007**
BH06/N	12/08/2013	EP1306149	10,800	6.84	2.4	9880	140	5	<0.05	5000	0.4	<0.01	47	3470	149	12	1940	146	101	415	<1	415	<1	***68.7***	**0.11**	0.002	<0.0001	**0.005**	0.003	0.001	***32.1***	1.32	0.001	0.591	0.004	<0.01	<0.005
BH08	12/08/2013	EP1306149	173	5.83	<0.1	212	60	1.4	0.28	1700	0.04	<0.01	10	23	3	1	25	57	30	11	<1	11	<1	**0.68**	**0.2**	<0.001	<0.0001	**0.002**	<0.001	**0.002**	2.66	1.74	<0.001	0.024	0.003	<0.01	**0.025**
BH10	13/08/2013	EP1306178	852	7.31	<0.1	1520	60	10.1	0.1	10,200	0.83	<0.01	11	101	15	2	165	52	40	274	<1	274	<1	***184***	**0.85**	0.002	<0.0001	**0.001**	<0.001	**0.005**	***52.6***	0.42	0.001	0.025	0.002	<0.01	**0.008**
BH11	13/08/2013	EP1306178	1580	7.84	<0.1	2180	20	0.9	0.02	900	0.16	<0.01	16	64	22	2	353	84	20	702	<1	702	<1	**16.7**	0.01	0.003	<0.0001	<0.001	0.001	**0.003**	***18.5***	<0.05	<0.001	0.151	0.004	<0.01	<0.005
BH12	13/08/2013	EP1306178	628	7.15	<0.1	600	50	4.2	4.31	8500	0.31	<0.01	67	38	20	2	43	97	36	167	<1	167	<1	***26.1***	**0.81**	0.004	<0.0001	**0.004**	0.002	**0.006**	***76***	1.07	**0.004**	0.091	0.006	<0.01	**0.008**
BH13	13/08/2013	EP1306178	375	6.3	<0.1	760	20	9	0.13	9100	8.17	<0.01	13	65	6	6	54	54	98	18	<1	18	<1	***540***	**0.04**	<0.001	<0.0001	<0.001	0.005	**0.002**	9.52	0.23	<0.001	0.097	<0.001	<0.01	<0.005
BH28	13/08/2013	EP1306178	20,800	7.12	<0.1	14,300	200	2.7	<0.01	2700	0.1	<0.01	97	7940	478	17	4640	727	65	368	<1	368	<1	**3.21**	0.02	0.002	<0.0001	**0.006**	0.014	**0.006**	9.78	3.79	<0.001	**1.5**	**0.021**	<0.01	**0.024**
Statistical Summary																																						
Number of Results			9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Number of Detects			9	9	2	9	9	9	7	9	8	2	9	9	9	9	9	9	9	9	0	9	0	9	9	6	0	5	6	8	9	8	4	9	7	0	5
Minimum Concentration			173	5.83	<0.1	212	20	0.9	<0.01	900	0.04	<0.01	10	23	3	1	25	52	20	11	<1	11	<1	0.51	0.01	<0.001	<0.0001	<0.001	<0.001	<0.001	0.6	<0.05	<0.001	0.015	<0.001	<0.01	<0.005
Minimum Detect			173	5.83	0.2	212	20	0.9	0.02	900	0.04	0.01	10	23	3	1	25	52	20	11	ND	11	ND	0.51	0.01	0.001	ND	0.001	0.001	0.001	0.6	0.08	0.001	0.015	0.001	ND	0.007
Maximum Concentration			20,800	7.84	2.4	14,300	880	10.1	12.2	17,000	8.17	0.25	97	7940	478	18	4640	727	113	702	<1	702	<1	540	0.85	0.004	<0.0001	0.006	0.014	0.006	76	3.79	0.004	1.5	0.021	<0.01	0.025
Maximum Detect			20,800	7.84	2.4	14,300	880	10.1	12.2	17,000	8.17	0.25	97	7940	478	18	4640	727	113	702	ND	702	ND	540	0.85	0.004	ND	0.006	0.014	0.006	76	3.79	0.004	1.5	0.021	ND	0.025
Average Concentration			4043	6.9	0.33	3380	164	4.4	2.6	6978	1.2	0.033	45	1312	80	7.3	811	153	58	250	0.5	250	0.5	93	0.27	0.0017	0.00005	0.0022	0.0031	0.0031	23	1	0.0012	0.29	0.0047	0.005	0.0091
Median Concentration			652	7.12	0.05	760	60	4.2	0.13	7700	0.31	0.005	47	65	15	6	54	84	40	199	0.5	199	0.5	16.7	0.11	0.002	0.00005	0.001	0.001	0.002	9.78	0.6	0.0005	0.091	0.003	0.005	0.007
Standard Deviation			7129	0.67	0.78	5097	275	3.3	4.3	5064	2.6	0.081	34	2730	156	6.7	1563	218	37	221	0	221	0	178	0.33	0.0012	0	0.0022	0.0044	0.0021	26	1.2	0.0012	0.49	0.0064	0	0.0091
Number of Guideline Exceedances			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	7	0	9	9	0	7	4	0	2	1	1	9	9
Number of Guideline Exceedances(Detects Only)			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	7	0	0	5	0	7	4	0	2	1	1	0	5

Appendix D – Dewatering Schematic

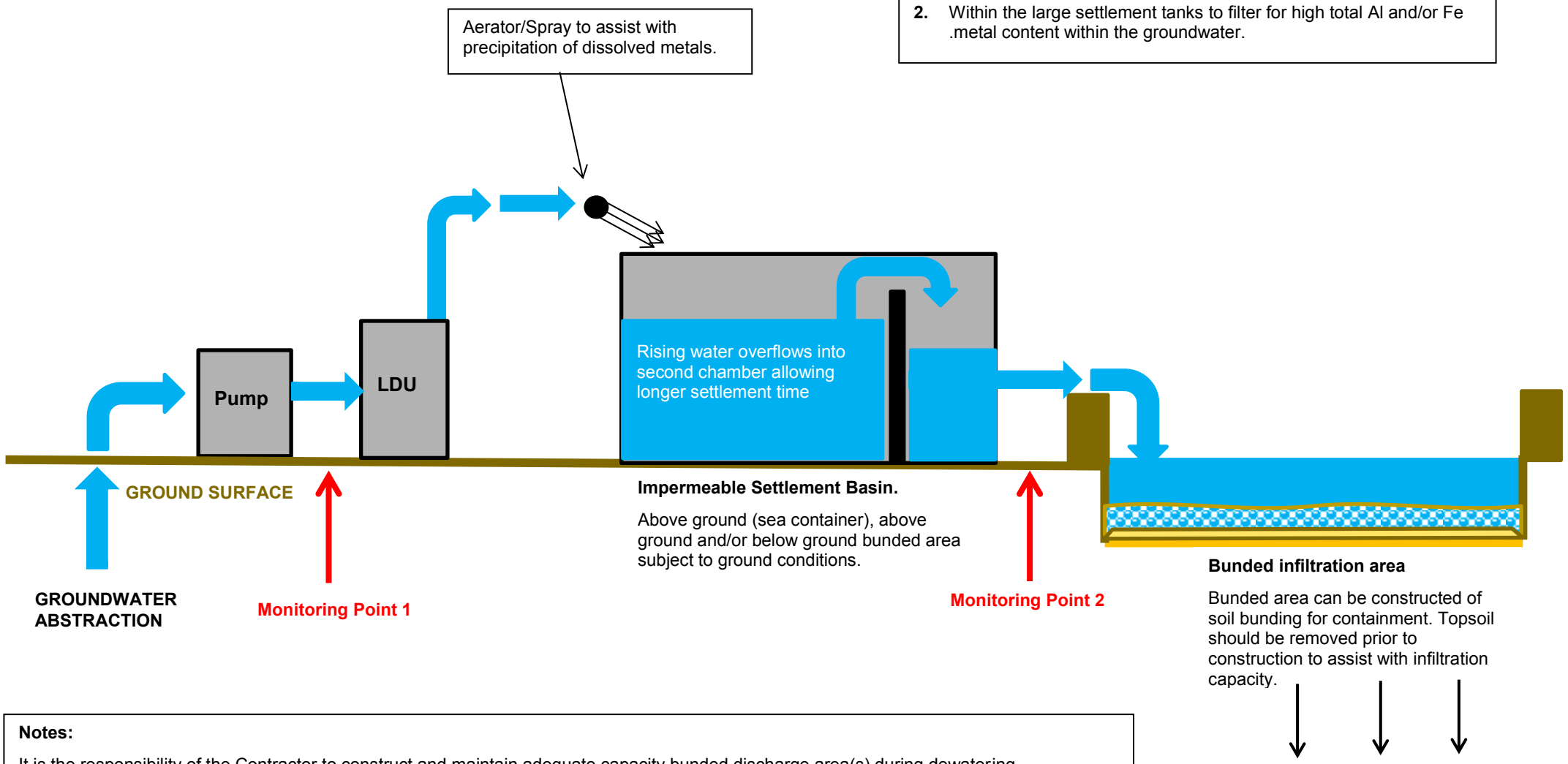
Example of Dewatering Treatment System

Geotextile Installation Notes

Geotextile only installed if effluent exceeds STI guideline post-retention (Principal's Environmental Consultant to advise when/if required.

Geotextile (pore size <0.3 mm) must be installed where either at:

1. At the base of the bunded discharge point OR
2. Within the large settlement tanks to filter for high total Al and/or Fe .metal content within the groundwater.



Notes:

It is the responsibility of the Contractor to construct and maintain adequate capacity bunded discharge area(s) during dewatering.

Lime Dosing Unit (LDU) is required if the pH is less than 6.00.

Schematic is not to scale and is a guide for treatment systems only.

Appendix E – Contractor Daily Record Sheets

DEWATERING FIELD RECORD SHEET

Date	Time	Flow rate (L/s)	Daily Total Volume of Dewatering Effluent (kL)	Water Quality Meter Calibrated?	Monitoring Point 1 (Before Treatment)				Monitorign point 2 (After Treatment)				kg of Lime used	Aeration/Settlement Tank in use? Inc geotextile fabric?	Discharge Location	Comments (filtered for acidity/alkalinity) / observations (colour, sediment load, odour)
					pH	EC (µS/cm)	TTA (mg/L)	TTAlk (mg/L)	pH	EC (µS/cm)	TTA (mg/L)	TTAlk (mg/L)				
Dewatering effluent pH is to remain >pH 6.75 and acidity is to be below 40 mg/L. If water quality falls 'outside' the aforementioned criteria, the Superintentendent's Representative (Water Corporation) and the nominated Environmental Consultant should be notified immediately.																

GROUNDWATER WELL FIELD MONITORING RECORD

Date	Time	Sampler	Well ID	Total Depth of Well (m TOC)	Depth to Water Level (m TOC)	Water Column (m)	Litres to purge *	pH	EC (µS/cm)	TTA (mg/L)	TAAlk (mg/L)	Comments: Condition of headworks, requirement for filtering and observations noted (colour, sediment load, odour)

Notes:
* Litres to purge = Water column (m) x 6
m TOC denotes measurements to be taken from top of the PVC casing

Contractor:	Acid Sulfate Soil Stockpile Report

	Comments	Onsite Person Responsible
Stockpile #		
Stockpile Location		
Where has the material come from?		
When was it first excavated?		
What is the volume of the stockpile?		
How much ag-lime is needed?		
What date was it treated / mixed?		
What date was it tested?		
Where has it been used for backfill?		

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	L. Cockerton	C. Gwynne		C. Gwynne		31/03/2014
Rev 0	L. Cockerton	D. Todd		D. Todd		17/04/2014

www.ghd.com

Appendix F

WAPC Correspondence

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Western Australian Planning Commission

Your ref: JT1 2011 12136 V01
Our ref: 805/02/01/0040P
Enquiries: Alex Harrison (6551 9420)

Carl Barbato
Project Manager
Locked bag 2
Osborne Park Delivery Centre
WA 6916

Dear Carl

PROPOSED BALANNUP WASTEWATER PRESSURE MAIN

Thank you for meeting with us and your subsequent letter dated 5 August 2014 detailing the proposed Wastewater pressure main through the Anstey-Keane Dampland (Bush Forever area 342).

Bush Forever area 342 is large area of regionally significant conservation category bushland that the Western Australian Planning Commission (WAPC) continues to manage. Bush Forever area 342 has a number of exposed boundaries that render it vulnerable to entry by unauthorised off road vehicles and illegal rubbish dumping. The remaining private properties also make the co-ordinated management of the overall area difficult.

The ever-present urban development front progressively surrounding the sites, together with an increased population, bring additional pressures including trail bike use, building material dumping and a greater risk of fires.

The WAPC has been proactive in working with local governments across the metropolitan area in dealing with Off Road Vehicle (ORV) use in particular. Even where fences and signs are installed, they are simply cut and in some instances gates 'ripped' from the ground. These impact the site and create ongoing management problems.

As discussed at our recent meeting the WAPC supports the proposed location of the pipeline within Lots 65 and 66 (part of Bush Forever area 342), subject to the following conditions.

- For any proposed clearing, an offset package is prepared and approved by the Department of Environmental Regulation prior to the clearing of any native vegetation, in accordance with the Environmental Protection Authority's Position Statement No. 9: Environmental Offsets and Appendix 4 of State Planning Policy 2.8. It would be recommended that there is a net environmental gain for any clearing undertaken, preferably with offset measures provided onsite at Bush Forever area 342.

Postal address: Locked Bag 2506 Perth WA Street address: 140 William Street Perth WA 6000
Tel: (08) 655 19000 Fax: (08) 655 19001 corporate@planning.wa.gov.au www.planning.wa.gov.au
ABN 35 482 341 493

- The Water Corporation will use the least invasive method of pipeline installation possible to ensure minimal impact to the flora and fauna along the proposed path along the confines of the existing track (as per the letter dated 5 August 2014).
- Any vegetation likely to be impacted during the pipeline installation is trimmed to minimise breakage and weakening of the plants.
- No building materials, rubbish or other matter is to be deposited into Bush Forever area 342 during or after construction works.
- The Water Corporation will reinstate the path to the pre-installation ground compaction to ensure minimal impact on the hydrology of the area.
- Excess soil from the pipeline installation after normal compaction to be removed from the site to the satisfaction of the WAPC.
- The Water Corporation will provide financial support for the development of a 'Reserve' management plan to ensure ongoing safety in the area.
- That the Water Corporation will not seek an easement for the pipeline across the WAPC's land (as per the letter dated 5 August 2014).

If this office can be of more assistance please contact Alex Harrison, A/Manager Property Operations at the Department of Planning on the contact details above.

Yours sincerely

Tim Hillyard
Secretary, WAPC

15/8/2014

Appendix G

Balannup Pressure Main Groundwater Assessment (RPS ,2014)

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RPS

38 Station Street, Subiaco, WA 6008 • PO Box 465, Subiaco 6904, Western Australia
T +618 9211 1111 F +618 9211 1122 E environment@rpsgroup.com.au W rpsgroup.com.au

Our Ref: I1420001

Email: carl.davies@rpsgroup.com.au
Date: 13 November 2014

Bree Atkinson
Environmental Scientist
Water Corporation
629 Newcastle Street
LEEDERVILLE WA 6007

Dear Bree

BALANNUP ROAD PRESSURE MAIN- GROUNDWATER ASSESSMENT

Objective

This report has been prepared to address Environmental Protection Authority (EPA) correspondence related to the installation of the Balannup wastewater pressure main (EPA Ref CMS 14335; AC01-2014-0150, 28 October 2014). The EPA correspondence identifies that the following additional information is required to make a determination on significance and appropriate level of assessment for the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to

    - Clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal.

    - Provide further discussion on whether there are any risks to ground water quality associated with the application of Aglime for neutralising soils as stated in the Draft Acid Sulfate Soil and Dewatering Management Plan (ASSDWMP).

The EPA correspondence is provided in Appendix 1. Essentially, the EPA has raised a concern that the 450 mm pressure main will form some sort of hydrological flow-barrier to groundwater (once installed), and that this might cause an impact on proximate wetland vegetation.

Scope

In order to address the EPA comments, the work scope includes preparation of a visual representation of the groundwater conditions before and after pressure main construction, based on outputs generated from a groundwater model. The modelling approach consists of the preparation of simple numerical "box models" to represent three scenarios that are based on natural site conditions:

1. 450 mm pressure main located within the Bassendean Sand unit (being approximately 2.5 m thickness, above clay)

2. 450 mm pressure main located within the Bassendean Sand, directly above a clayey unit.

3. 450 mm pressure main located within the clayey unit.

The box models include relevant hydrogeological parameters such as groundwater recharge (from rainfall), evapotranspiration (ET), groundwater inflow and outflow, and soil parameters such as hydraulic conductivity (K) and storage. The above scenarios capture the general geological conditions along the alignment.

Groundwater level changes have in turn been compared with generic ecological water requirements (EWRs) for wetlands of the Swan Coastal Plain. These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and can be used to provide "risk of impact" categories for wetlands.

This approach was approved in principle by the EPA (pers. comm. Amy Sgherza, 3 November 2014), provided that suitable, up to date information was used in the model. The EPA email correspondence is provided in Appendix 2.

Geology

As described in the EPA referral supporting documentation (AECOM 2014)[1], bore sampling was conducted by GHD (2013)[2] along the entire proposed alignment. Two distinct geological areas were encountered within Bush Forever Site 342. The first section is approximately 320 m in length located from Skeet Rd to the east and typically consists of Bassendean Sand to 2.5 metres below ground level (mbgl), overlying a layer of medium dense to dense silty sand. The second section is approximately 1,200 m in length and is located directly east of the first section to Anstey Road. This second section generally consists of a thin layer of Bassendean Sand (0.5 to 2 m) overlying sandy clay/ clayey sand.

Soils along the alignment outside of the Bush Forever site were highly variable which is partly due to the disturbance of soil associated with the development. It was noted by GHD (2013) that the soils west of Skeet Road contain strongly cemented coffee rock, while east of Anstey Road the pressure main may intersect strongly cemented clayey sand, however much of this layer may be below the depth of the proposed pipeline.

[1] AECOM 2014. Balannup Wastewater Pressure Main. Supporting Documentation
[2] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

The pressure main is proposed to be installed to 1.5 m depth. It is expected to be wholly in Bassendean Sand at the western part of the alignment, which extends to 2.5 mbgl in this area. The pressure main is expected to penetrate into the sandy clay/ clayey (Guildford Formation) along the eastern part of the alignment, which is located at depths of between 0.5 and 2 mbgl.

Groundwater

Groundwater in the immediate area is generally shallow, and encountered in Bassendean Sands overlying lower permeability Guildford Formation soils. Groundwater and surface water drainage in the area is facilitated by numerous open drains which have a controlling influence on groundwater levels.

Groundwater monitoring along the proposed pressure main alignment indicates groundwater to the southeast of the alignment migrates in a west to north-westerly direction towards the Jandakot Regional Park wetland area (approximately 23 m AHD at the south-east end of the alignment to the wetland). Conversely, groundwater to the north-west of the alignment migrates in an east to south-easterly direction towards the wetland area (approximately 25 m AHD at the north-western end of the alignment to the wetland), indicating the wetland acts as a local discharge area for groundwater. Appendix 3 provides groundwater elevation information, including levels along the alignment and regional flow patterns as provided by Department of Water (DoW 2014)[3].

Groundwater Modelling

Groundwater modelling was undertaken to predict groundwater impacts associated with the pressure main installation for the three scenarios described previously, i.e. pressure main within sand (Scenario 1), pressure main located on the clayey sand surface (Scenario 2) and pressure main within the clayey sand (Scenario 3). Two separate model grids were created to take into account the variable groundwater flow direction and geology between the western and eastern parts of the alignment.

The modelling predicted minimal (< 5 cm) of groundwater level change immediately adjacent to the pressure main for all three scenarios, indicating pressure main installation has a negligible influence on groundwater flows. Details of the modelling methodology and results are provided in Appendix 4.

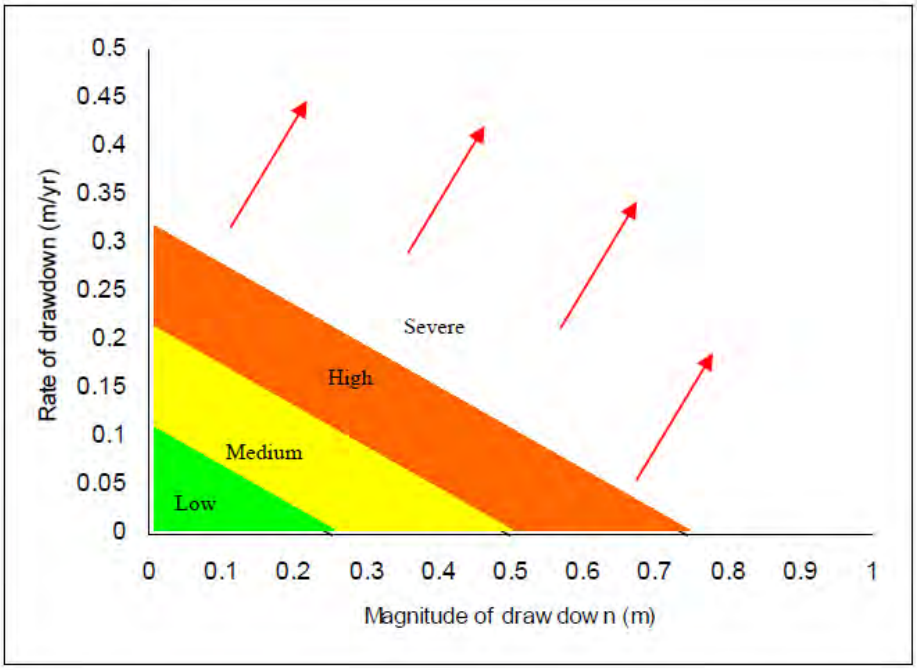
Wetland Ecological Water Requirements

The risk of impact associated with water level changes can be provided by comparison with generic Ecological Water Requirements (EWRs) established by DoW for the Swan Coastal Plain and Blackwood region (Hyde 2006). These generic EWRs relate to maximum drawdown limits and rate of change limits for wetlands and phreatophytic vegetation. The DoW document includes "risk of impact" categories for wetlands that were developed by Froend and Loomes (2004)[4].

[3] DoW (2014). Perth Groundwater Atlas

[4] Froend, R. and Loomes, R. 2004. Approach to determination of ecological water requirements of groundwater dependent ecosystems in Western Australia – A report to the Department of Environment, Edith Cowan University, Perth.

As stated in Hyde (2006)[5], the categories were developed based on the results of research into the response of vegetation to groundwater decline. The cumulative rate and magnitude of the predicted groundwater drawdown is defined and the possible ecological responses to the varying degrees of drawdown are described broadly as either low, moderate, high or severe in terms of probability of noticeable impact from groundwater level change. The risk categories for wetlands are shown on Graph 1.



Froend and Loomes 2004

Graph 1: Risk of Impact for Wetland Vegetation based on Magnitude of Groundwater Level Change

On this basis, the model predicted water level change associated with pressure main installation is expected to result in a low risk of impact to wetlands.

Aglime Impact to Groundwater Quality.

The application of aglime to neutralise acid sulfate soils (ASS) is not considered to pose a significant risk to groundwater given its low solubility and weak base nature. Aglime is considered the industry standard for treating ASS and acidic dewatering effluent as described in *Treatment and Management of Soils and Water in Acid Sulfate Soil Landscapes* (DER July 2011) and is also generally not harmful to plants, livestock, humans and most aquatic species. As such it is considered suitable for use near water bodies.

Due to aglimes' low solubility, weak basic nature and its low dissociation constant, any impact on the chemistry of groundwater would be very slow and as a result the groundwater system is likely to be able to buffer any addition of bicarbonate to the system. Thus the buffering capacity of the groundwater and the low solubility of the aglime results in minimal potential for the pH to rapidly change and increase to highly basic. As such the aglime is not considered to pose a significant risk to groundwater.

[5] Hyde, N.L. (2006). A summary of investigations into ecological water requirements of groundwater-dependent ecosystems in the South West groundwater areas.

Furthermore, given the aglime is being applied to ASS, the aglime is expected to protect the groundwater from potential acidification impacts as a result of ASS oxidation during earthworks. These acidification products pose a greater risk to groundwater, should they not be managed, than the use of aglime to manage the potential acidification products. Any generated acidification products will react with the aglime and be neutralised and thus consume the aglime, reducing the concentration of aglime in the soil. As a result, the aglime concentration will decrease over time and therefore the potential for any impacts will be further decreased. It should be noted that the treatment of the ASS should result in an excess of aglime being added to the soils and as such more neutralising capacity will be added to the soils than required. However as previously stated this is considered to pose a smaller potential environmental risk than not treating the ASS.

Conclusion

Groundwater modelling has been undertaken to estimate the impact of the Balannup pressure main on nearby hydrological processes. The models utilised site specific hydrogeological information and the results indicate the pressure main will not have significant direct or indirect impacts on the subsurface flows at the site. This meets the EPA's objective which is to maintain the hydrological regime so that existing and potential uses, including ecosystem maintenance, are protected. In relation to groundwater quality, the use of aglime is the recommended option for treating ASS and its use is not expected to result in any risk to groundwater quality.

Yours sincerely
RPS

CARL DAVIES
Principal Hydrogeologist

ATTACHMENTS

Appendix 1: *EPA Referral Comments*
Appendix 2: *EPA Email Correspondence*
Appendix 3: *Groundwater Elevation Information*
Appendix 4: *Groundwater Modelling*

APPENDIX 1

EPA Referral Comments

Mr Rupert Duckworth
Manager EIA and Approvals
Environment and Aboriginal Affairs Branch
Water Corporation
PO Box 100
LEEDERVILLE WA 6902

Your Ref: *JT1 2011 12136v01*
Our Ref: *CMS 14335; AC01-2014-0150*
Enquiries: *Amy Sgherza, 6145 0818*
Email: *amy.sgherza@epa.wa.gov.au*

Attention: Ms Bree Atkinson

Dear Mr Duckworth

NOTICE REQUIRING FURTHER INFORMATION
s38A of the *Environmental Protection Act 1986*

PROPOSAL: **BALANNUP WASTEWATER PRESSURE MAIN**
PROPONENT: **WATER CORPORATION**

Thank you for your letter dated 3 October 2014 referring the above proposal to the Environmental Protection Authority (EPA) under section 38 of the *Environmental Protection Act 1986* (EP Act).

This means that the EPA is required to:

- determine the significance of the effect on the environment of the proposal, if implemented, and
- make a decision on whether or not to assess the proposal and, if the decision is to assess, the level of assessment.

The EPA considers that it does not have enough information about the proposal to enable it to make decisions on significance and appropriate level of assessment. Accordingly, the EPA requests that you, as the proponent, provide it with the following additional information about the proposal:

- Further information in relation to the predicted hydrological changes that may occur as a result of the installation of the pipeline are required to demonstrate that the EPA's objective for hydrological processes which is *to maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected*, can be met, following construction.

- Based on existing knowledge and available information regarding hydrology and stratigraphy for the Keane Road section (Bush Forever 342) the referral document needs to:
    - clearly demonstrate that the proposal would not have significant direct and indirect impacts on the subsurface flows at the site. This includes describing the current hydrological regimes and processes that operate at the site (at the local-scale) and how they may be disrupted due to the proposal. This could be set out for example, by using cross-sectional figures of the soil profile showing current hydrological processes/flows, compared with one showing the potential effects of the proposal; and
    - provide further discussion on whether there are any risks to ground water quality associated with the application of AgLime for neutralising soils as stated in the Draft Acid Sulphate Soil and Dewatering Management Plan (ASSDWMP).

Should you have any enquiries please contact the person cited above.

Your response to this request for additional information is required by 17 November 2014. Please respond with either:

a) the information requested; or

b) advice that further information is not available and/or cannot be obtained.

Please note that the EPA has also sought additional information about the proposal from the Department of Parks and Wildlife, the Department of Water, the City of Armadale and the Department of Planning.

Your response should be sent by email to registrar@epa.wa.gov.au marked for the attention of the person cited above, or by post to the Office of the Environmental Protection Authority, Locked Bag 10, East Perth WA 6892. Please quote the above "Our ref" on any further correspondence.

It should be noted that, under the EP Act, the EPA has 28 days in which to make a decision on whether or not to assess a proposal, and if assess, the appropriate level of assessment. The 28-day period will start to run either on 17 November 2014, i.e. the expiration of the specified period, or on receipt of the requested information, whichever occurs first. However, if the information is not received within the specified period, or if it becomes apparent that such information is not available, the EPA can proceed (at the expiration of the specified period) to make its decision on whether or not to assess and if assess, the appropriate level of assessment, based on information derived from its own investigations and inquiries.

You would be notified once the EPA has made a decision.

Yours sincerely

Anthony Sutton
Director
Assessment and Compliance Division

For the Chairman of the Environmental Protection Authority
Under Notice of Delegation No. 33 dated 6 December 2013

28 October 2014

APPENDIX 2

EPA Email Correspondence

Doris Clarke

From: Bree Atkinson <Bree.Atkinson@watercorporation.com.au>
Sent: Monday, 3 November 2014 4:04 PM
To: Carl Davies
Cc: Carl Barbato
Subject: FW: Balannup - Proposal

FYI comments from the oEPA regarding their review of the scope of works.

Thanks
Bree

From: Amy Sgherza [mailto:Amy.Sgherza@epa.wa.gov.au]
Sent: Monday, 3 November 2014 3:50 PM
To: Bree Atkinson
Subject: RE: Balannup - Proposal

Hi Bree,

I provide the following comments in relation to the proposed scope of works (RPS).

In general, the scope of works is adequate, but please be aware that the model output is only going to be as good as the information inputted, so please ensure that the most up to date available information is utilised. Also, once the models are generated it will be necessary to then relate the results back to the EPA's objective for Hydrological Processes with a discussion on whether this objective will be met.

Thank you. Any questions please do not hesitate to contact me. I will be back in the office on Wednesday.

Kind regards

Amy Sgherza
Environmental Officer
Office of the **Environmental Protection Authority**
The Atrium, Level 8, 168 St Georges Terrace, Perth
Locked Bag 10, East Perth WA 6892
direct: 08 6145 0818| reception: 08 6145 0800 | fax: 08 6145 0895
email: amy.sgherza@epa.wa.gov.au | web: http://www.epa.wa.gov.au
@EPA_WA

Please note new postal address and phone and fax numbers.

Office of the
Environmental Protection Authority

From: Bree Atkinson [mailto:Bree.Atkinson@watercorporation.com.au]
Sent: Friday, 31 October 2014 1:59 PM
To: Amy Sgherza
Subject: Balannup - Proposal

Hi Amy

I really appreciate you agreeing to have a look at RPS's proposal (attached)

We will also address the potential impact of adding aglime to manage Acid Sulfate Soils.

Thanks for your help

Bree Atkinson
Environmental Scientist
Environment & Aboriginal Affairs
Water Corporation
T: (08) 9420 2893
629 Newcastle Street, Leederville, WA 6007
PO Box 100, Leederville, WA 6902

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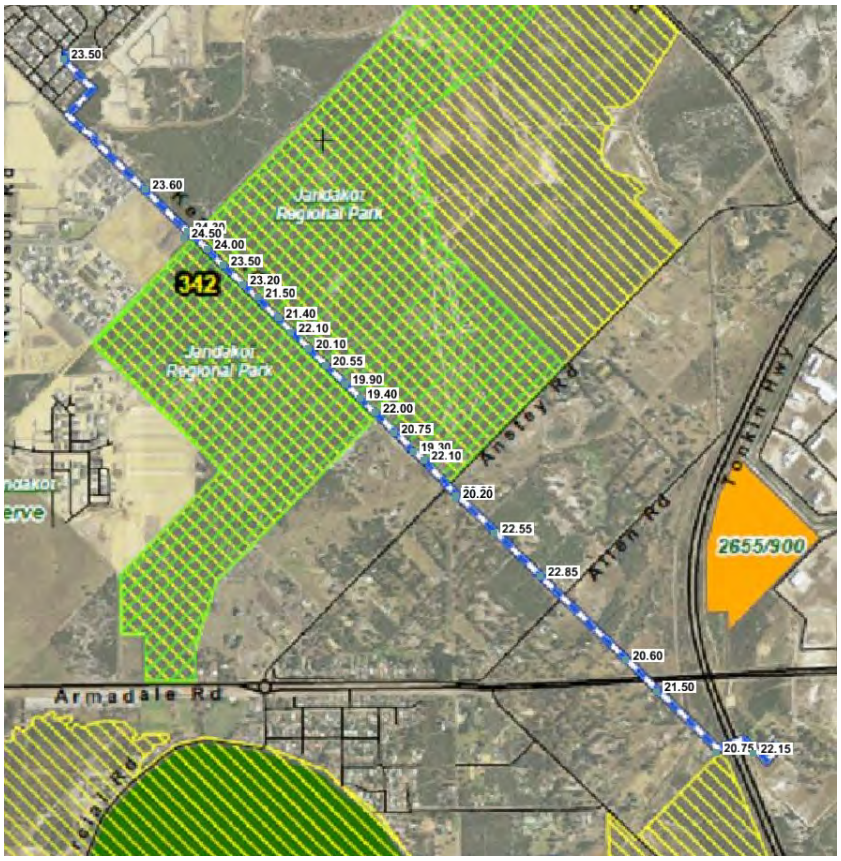
APPENDIX 3

Groundwater Elevation Information

APPENDIX 3: GROUNDWATER ELEVATION INFORMATION

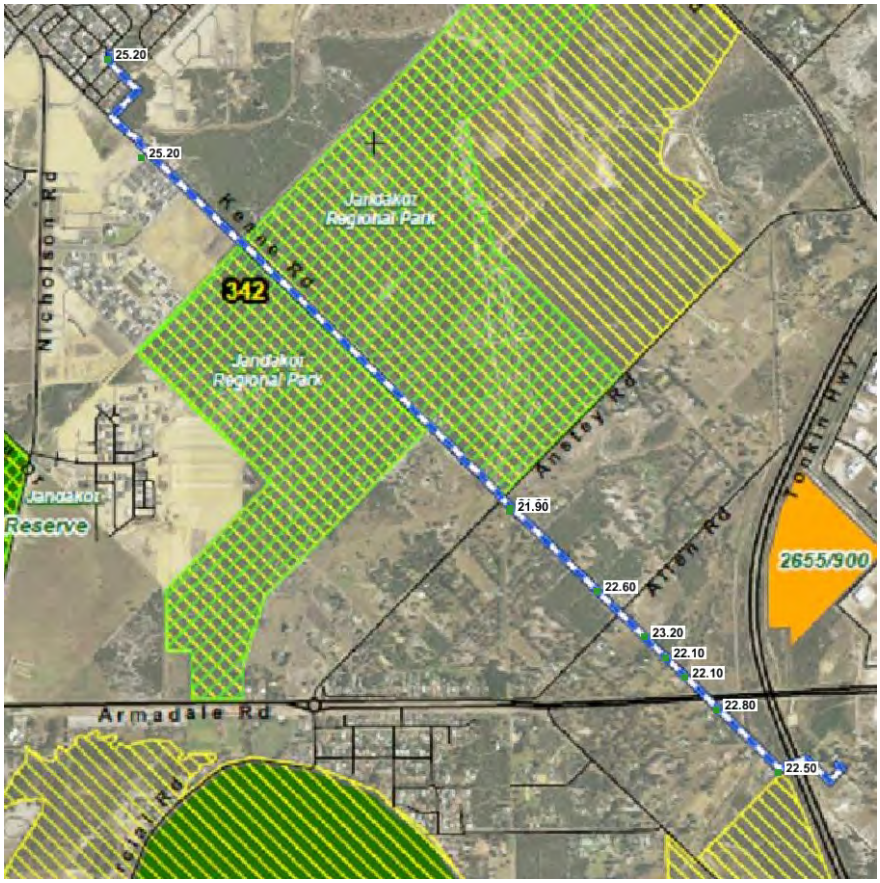
Table A3-1 Groundwater Monitoring Data (Modified from GHD 2013)

Bore	Chainage (m)	x	y	Topo Elevation (mAHD)	Depth achieved (mAHD)	Estimate GW Depth (June-July 2013)- mbgl	Bore Installed?	GWL June-July 2013_(mAHD)	GWL August 2013_(mAHD)
BH01	47	398909	6445341	26.8	3.45	3.3	Yes	23.5	25.2
BH02	353	398919	6445115	26.5	3.45	-	No		
BH03	570	399047	6444936	27	3.45	-	Yes		25.2
BH04	819	399252	6444789	25.5	3.45	1.9	No	23.6	
BH05N	1073	399432	6444610	25.5	2.86	1.2	Yes	24.3	
BH05S	1080	399417	6444584	25.4	2.5	0.9	Yes	24.5	
BH06N	2667	400565	6443495	22	6	1.8	Yes	20.2	21.2
BH06S	2674	400563	6443483	22.5	6.45	2.3	Yes	20.2	21.9
BH07	2895	400728	6443335	23.75	3.45	1.2	No	22.55	
BH08	3161	400922	6443153	24.25	2.8	1.4	Yes	22.85	22.6
BH09	3432	401117	6442965	24.3	3.45	-	No		23.2
BH10	3665	401281	6442799	23.4	4.5	2.8	Yes	20.6	22.1
BH11	3853	401414	6442667	23.5	4.5	2	Yes	21.5	22.8
BH12	4199	401666	6442408	23.75	4.5	3	Yes	20.75	22.5
BH13	4395	401821	6442405	24.75	4.5	2.6	Yes	22.15	
BH14	1183	399514	6444537	24.9	6.45	0.9	No	24	
BH15	1281	399583	6444467	25	6	1.5	No	23.5	
BH16	1396	399664	6444386	24.4	6	1.2	Yes	23.2	
BH17	1480	399729	6444332	24.5	6	3	No	21.5	
BH18	1603	399815	6444245	24	6	2.6	No	21.4	
BH19	1685	399869	6444183	23.9	6	1.8	Yes	22.1	
BH20	1784	399943	6444116	23.6	6.45	3.5	No	20.1	
BH21	1886	400014	6444044	23.75	6.45	3.2	No	20.55	
BH22	2000	400097	6443966	23.8	6	3.9	Yes	19.9	
BH23	2087	400159	6443905	23.4	6.45	4	No	19.4	
BH24	2177	400226	6443844	22.9	6.45	0.9	No	22	
BH25	2293	400303	6443757	22.75	6	2	Yes	20.75	
BH26	2409	400386	6443680	22.3	6.45	3	No	19.3	
BH27	2465	400430	6443644	22.3	6	0.2	No	22.1	
BH28	3553	401204	6442881	23.25	3	-	Yes		22.1



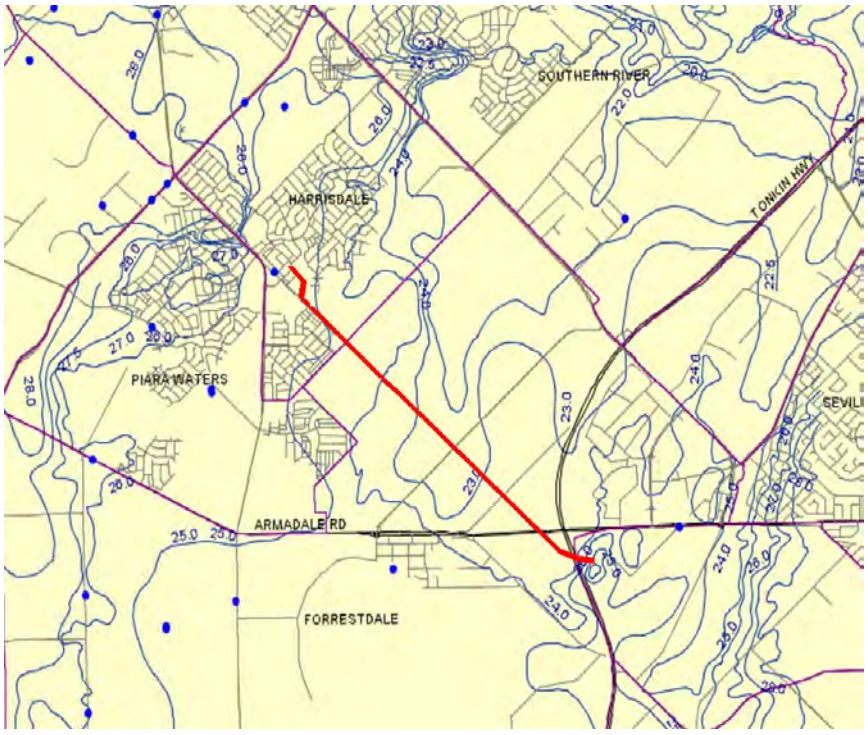
Source: GHD 2013 and AECOM 2014

Figure A3-1: Estimated Groundwater Elevation along Alignment- July 2013



Source: GHD 2013 and AECOM 2014

Figure A3-2: Estimated Groundwater Elevation along Alignment- August 2013



(DoW 2014)

Figure A3-3: Regional Groundwater Contours

APPENDIX 4

Groundwater Modelling

APPENDIX 4: GROUNDWATER MODELLING

Scenario 1: Western Model

Model Grid

Scenario 1 (pressure main located within the Bassendean Sand unit of approximately 2.5 m thickness) was simulated by constructing a model along the western side of the alignment.

A pre-installation model was initially constructed to use for comparison purposes. The model was constructed using Modflow NWT[1]. The model is approximately 1350 m × 840 m in dimension and the cell size ranges from 0.45 m along the pressure main (area of interest) and progressively increases to a maximum cell size of 20 m towards the model boundaries (Figure 1)[2]. The model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main within sand (1.05 to 1.5 mbgl).
- Layer 3 – bottom of pressure main to top of clayey sand (1.5 to 2.5 mbgl).
- Layer 4 – clayey sand top (2.5 mbgl) to base of superficial aquifer (-7 m AHD as provided by DoW 2014[3]).

Boundaries

Specified head boundaries were used at the western (25 m AHD) and eastern (24 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013[4]) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries (Figure A4-1).

[1] Modflow NWT allows simulation of cell drying/ rewetting due to the shallow water tables in the area
[2] Small cell sizes are also shown in Figure 1 perpendicular to the drain, which is necessary as part of the model grid process.
[3] DoW (2014). Perth Groundwater Atlas
[4] GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation

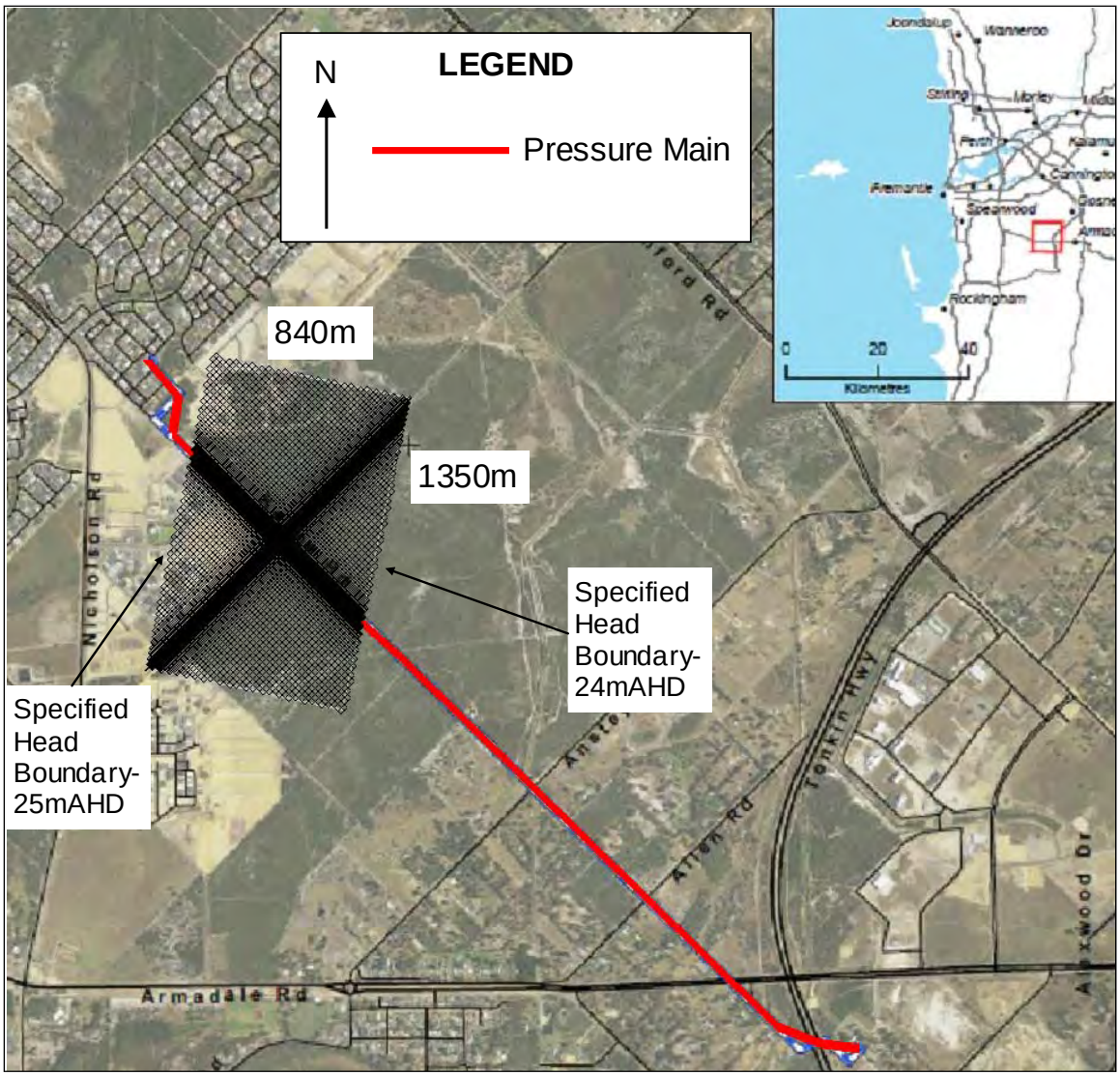


Figure A4-1: Scenario 1 Model Grid (Modified from AECOM Basemap)

Aquifer Properties

Aquifer properties were based on literature values (e.g. Davidson 1995[5]) for the geological unit, as summarised in Table A4-1.

Table A4-1: Aquifer Properties

Geological Unit	Hydraulic Conductivity (m/d)	Horizontal to Vertical K ratio	Specific Yield	Location
Bassendean Sand	15	3	0.2	Layers 1 to 3
Clayey Sand	1	10	0.07	Layer 4

[5] Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Geological Survey of Western Australia Bulletin 142.

Groundwater Recharge

The model utilises average monthly rainfall data from the Forrestdale weather station and monthly evaporation values from Medina weather station. Net recharge was simulated by applying a gross 50% rainfall recharge value with an evapotranspiration (ET) function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 1.5 mbgl.

Scenario 1 Pre-Installation Groundwater Levels

Pre-installation simulated groundwater contours are shown on Figure A4-2. Graph A4-1 shows a groundwater elevation time series for a point near the centre of the model domain, along the proposed main installation. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area (cf. Davidson 1995).

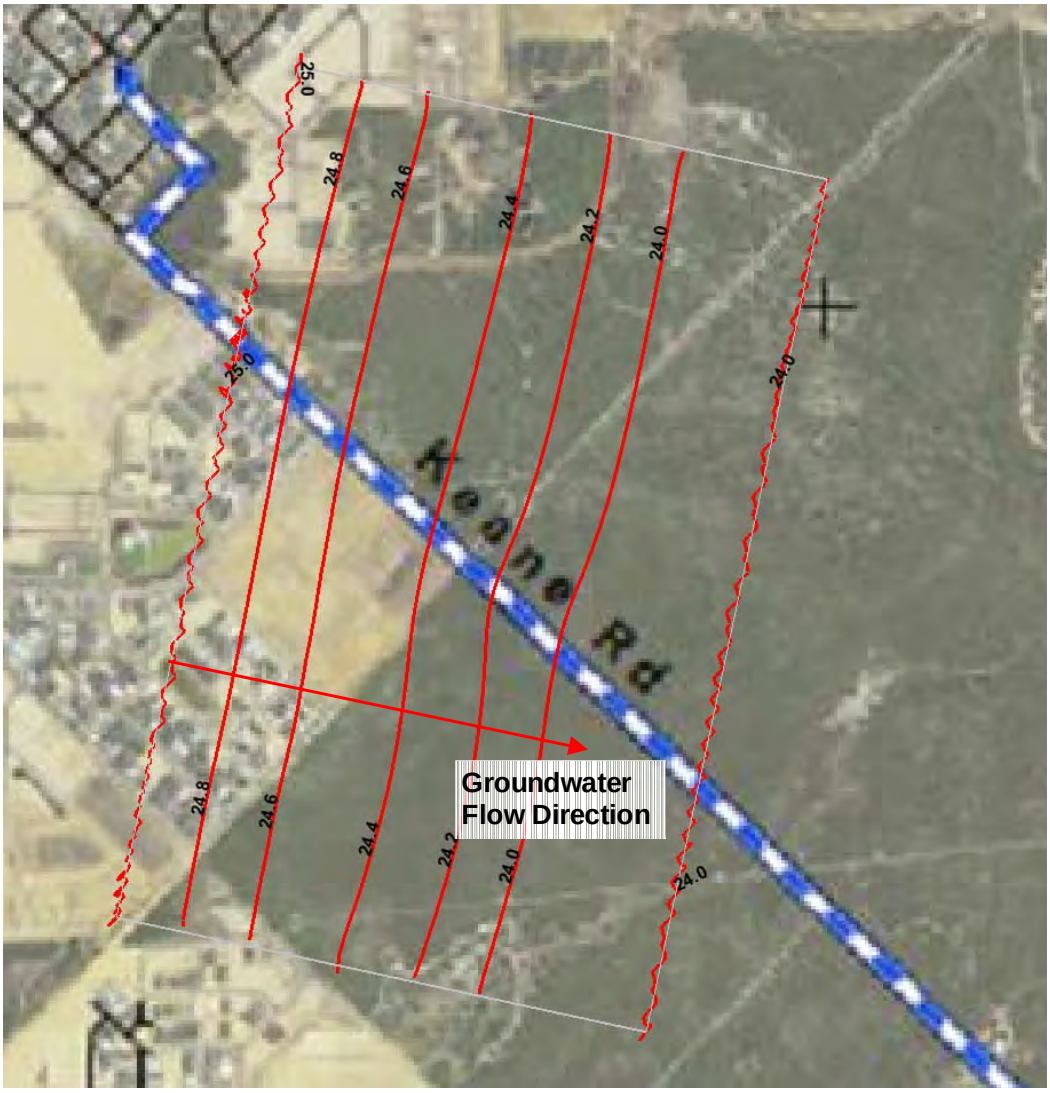
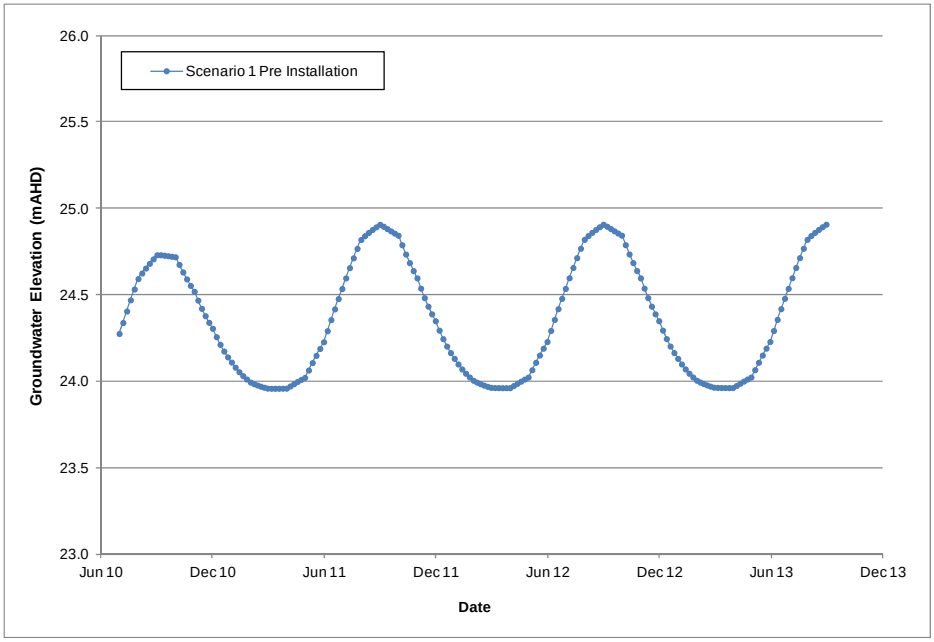


Figure A4-2: Scenario 1 Pre Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

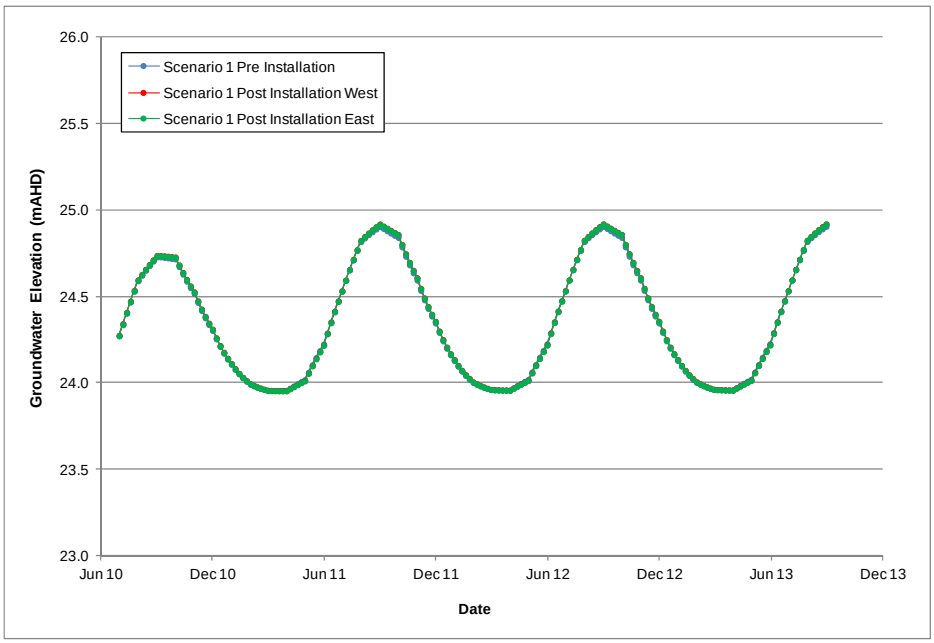


Graph A4-1: Scenario 1 Pre Installation Groundwater Elevation Time Series

Scenario 1 Post-Installation Groundwater Level Change

The pre installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-8} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (<1 cm) directly adjacent[6] to the pressure main for Scenario 1 (Graph A4-2).



Graph A4-2: Scenario 1 Groundwater Elevation Time Series– Adjacent to Pipe

[6] Simulated groundwater levels taken from 0.5 m cells directly adjacent to the pressure main

Scenarios 2 and 3: Eastern Model

Model Grid

Scenarios 2 and 3 (pressure main located *on* clayey sand and *within* clayey sand respectively) were simulated by constructing a model along the eastern side of the alignment. A pre-installation model was initially constructed to use for comparison purposes for Scenarios 2 and 3. The model is approximately 1675 m × 1020 m in dimension (Figure A4-3) and the cell size ranges from 0.45 m along the pressure main and progressively increases to a maximum cell size of 20 m towards the model boundaries.

The Scenario 2 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2- pressure main located on clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand top (1.5 mbgl) to base of superficial aquifer (-7 m AHD).

The Scenario 3 model has four layers with characteristics as follows:

- Layer 1 – topographic surface to top of pressure main.
- Layer 2 – pressure main within clayey sand (1.05 to 1.5 mbgl).
- Layers 3 and 4 – clayey sand to base of superficial aquifer (-7 m AHD).

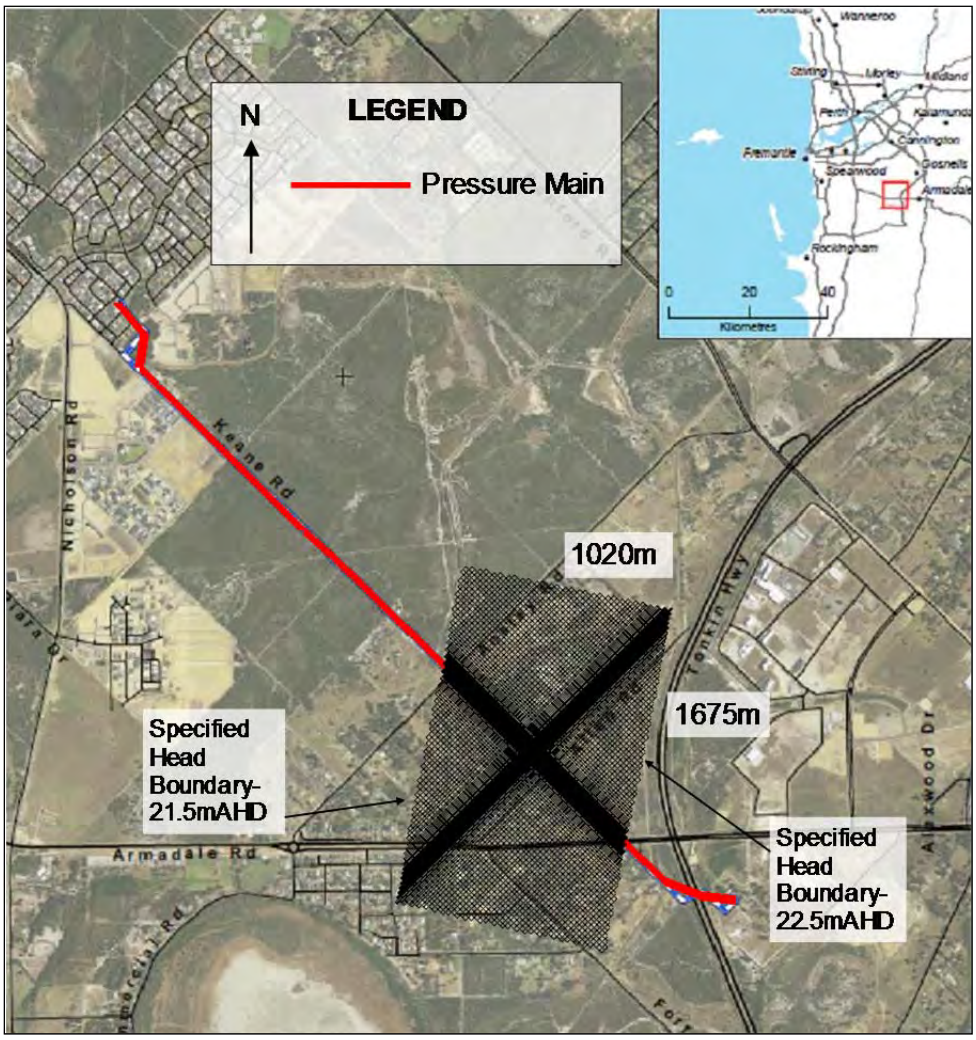


Figure A4-3: Scenarios 2 and 3 Model Grid (Modified from AECOM Basemap)

Boundaries

Specified head boundaries were used at the western (21.5 m AHD) and eastern (22.5 m AHD) ends of the model to coincide with groundwater levels as determined by measured site data (GHD 2013) and DoW (2014) mapping. No flow boundaries were used along the northern and southern boundaries.

Aquifer Properties

Aquifer properties were as per the previous model.

Groundwater Recharge

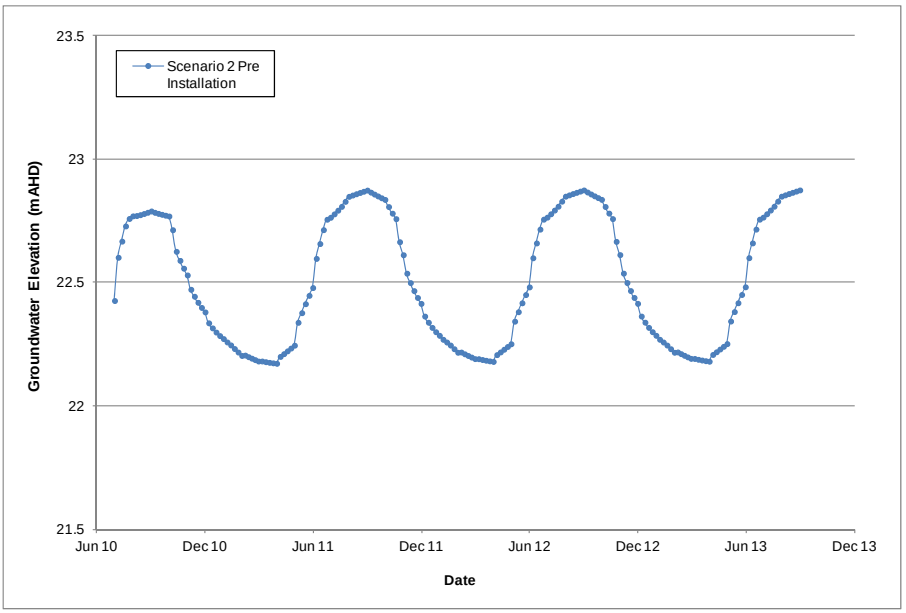
Net recharge was simulated by applying a gross 30% rainfall recharge value with an ET function of 0.8 pan evaporation at the ground surface that decreases linearly to zero at 2 mbgl.

Scenario 2 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-4) correspond with the measured flat water table east of the open drain (which is in close proximity to the western

boundary). Graph A4-3 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 0.8 m which is reasonable for the area.

Figure A4-4: Scenario 2 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

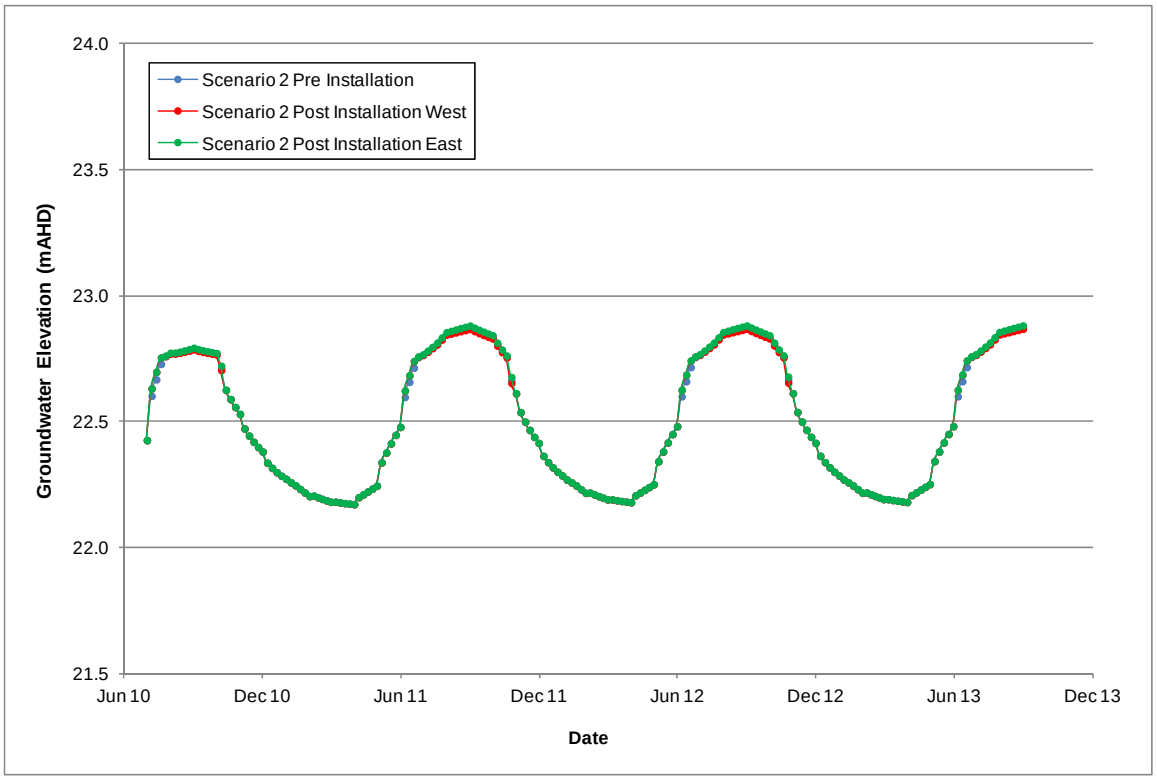


Graph A4-3: Scenario 2 Pre-Installation Groundwater Elevation Time Series

Scenario 2 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d[7] along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulated minimal groundwater elevation change (maximum 3 cm) directly east and west of the pressure main for Scenario 2 (Graph A4-4).



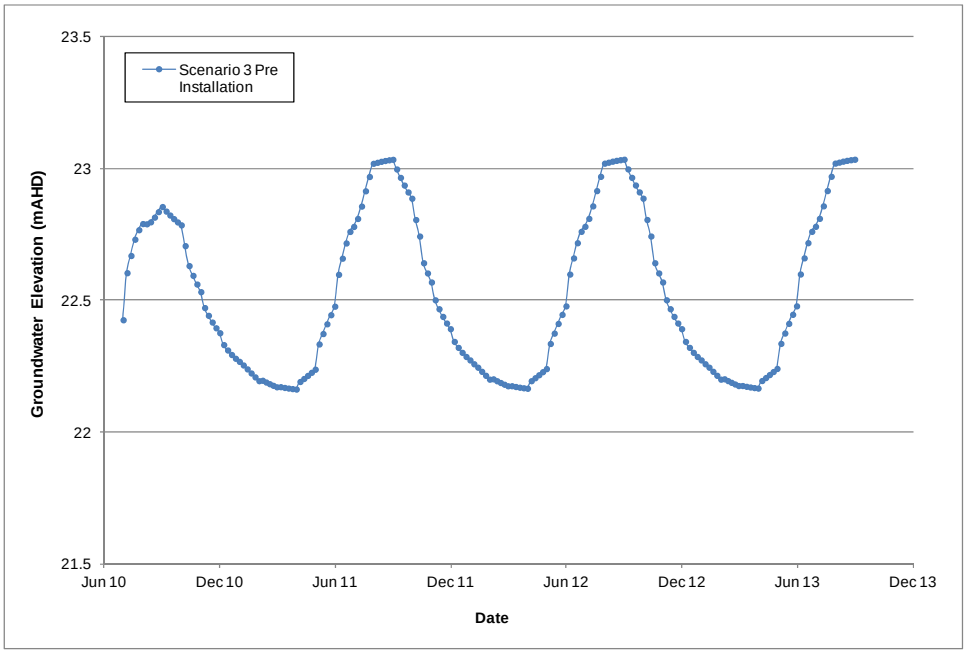
Graph A4-4: Scenario 2 Groundwater Elevation Time Series – Adjacent to Pipe

Scenario 3 Pre-Installation Groundwater Levels

Pre-installation model simulated groundwater contours (Figure A4-5) correspond with the measured flat water table east of the open drain (which is in close proximity to the western boundary). Graph A4-5 shows a groundwater elevation time series for a point along the proposed main installation, near the centre of the model domain. The model simulated groundwater contours fluctuate approximately 1 m which is reasonable for the area.

[7] A lower value was not used due to model convergence issues. This value is still 10,000 times less than the clayey sand K value and 150,000 times less than the sand K value.

Figure A4-5: Scenario 3 Pre-Installation Groundwater Contours - August 2013 (Modified from AECOM Basemap)

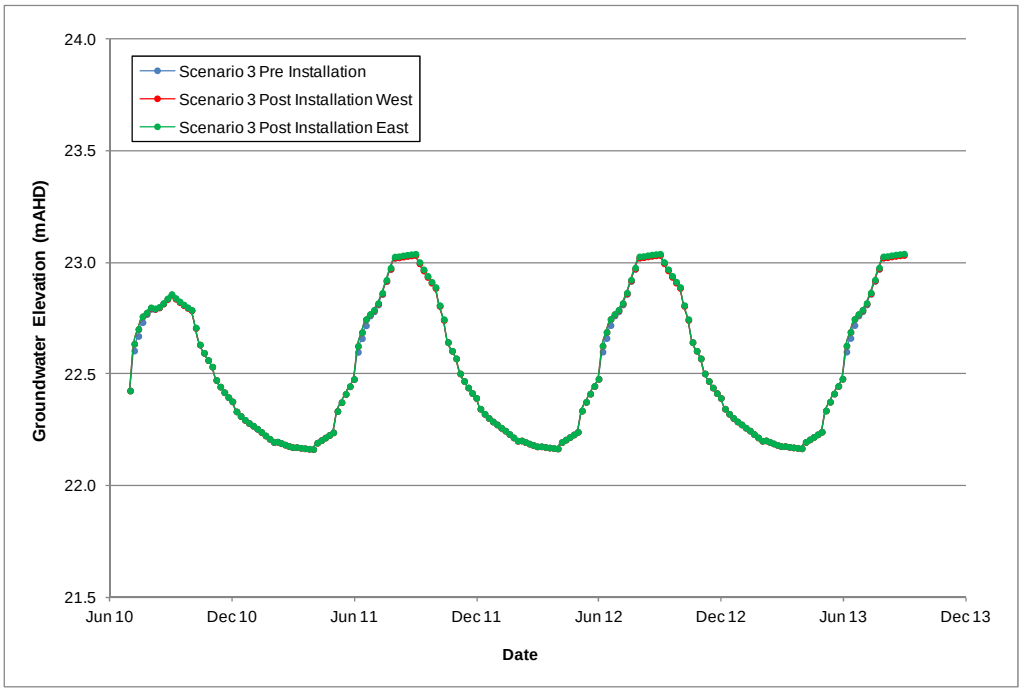


Graph A4-5: Scenario 3 Pre-Installation Groundwater Elevation Time Series

Scenario 3 Post-Installation Groundwater Level Change

The pre-installation model was modified to simulate the impact of the pressure main. This was undertaken by applying a low hydraulic conductivity (K) value of 10^{-4} m/d along the 0.45 m × 0.45 m cells in Layer 2 (depth of 1.05 to 1.5 mbgl).

The model simulates minimal groundwater elevation change (maximum ~3 cm) directly east and west of the pressure main for Scenario 3 (Graph A4-6).



Graph A4-6: Scenario 3: Groundwater Level Change Time Series– Adjacent to Pipe

References

AECOM 2014. Balannup Wastewater Pressure Main. Supporting Documentation

Davidson, W. A. 1995. Hydrogeology and Groundwater Resources of the Perth Region Western Australia. Geological Survey of Western Australia Bulletin 142.

DoW (2014). Perth Groundwater Atlas

GHD. 2013. Water Corporation Balannup A WWPS and Keane Road Pressure Main Report on the Geotechnical, ASS and Contaminated Sites Investigation