

This chapter describes the surface and groundwater features in the vicinity of the Proposal, and assesses the potential impacts of the construction and operation of the Proposal on the surface and groundwater hydrology, flooding and water quality of the study area. Measures to mitigate potential impacts are also identified.

9.1 Existing hydrological environment

9.1.1 Major catchments and surface water features

The Proposal crosses through three main catchments with areas greater than 50 km², three medium-sized catchments with areas between 2 km² and 50 km², and a series of minor sub-catchments. The three main catchments and waterways are:

- Stewarts River (flows into Watson Taylors Lake)
- Camden Haven River (flows into Watson Taylors Lake)
- Herons Creek (flows into Queens Lake).

These waterways flow predominantly eastwards prior to their confluences with the lakes and ultimately drain into the Pacific Ocean at North Haven via the Camden Haven Inlet.

Figure 9-1 shows the major catchment areas and surface water features in the study area.

Stewarts River

Stewarts River has a catchment of 103 km² upstream of the Pacific Highway and crosses the highway just north of Johns River. The catchment extends westwards to include parts of the Lansdowne State Forest. Major tributaries of the Stewarts River are Starrs Creek and Deep Creek. The existing highway crosses the Stewarts River about 1 km north of Johns River. The river flows into Watson Taylors Lake approximately 5 km downstream of the highway crossing.

The catchment area is characterised by forested uplands and rural areas. The river flows predominantly eastwards through steep gradients and small floodplains before giving way to a broad and flat valley system flanked by steep forested hills with elevations ranging up to 542 m AHD near its headwaters at Flat Rock Lookout approximately 25 km to the west of the highway crossing.

Camden Haven River

The Camden Haven River is the largest watercourse in the study area with a catchment area of 257 km² upstream of the highway. The catchment extends westwards to the Broken Bago Range and includes large areas of State Forest (e.g. Broken Bago, Lorne, Kerewong, Comboyne and Upsalls Creek State Forests).

The major tributaries of the Camden Haven River are Black Creek (northwest) and Upsalls Creek (west), McLeods Creek (west) and Gills Creek (southwest).

The existing highway crosses the Camden Haven River near the settlement of Rossglen, approximately 5 km upstream from Watson Taylors Lake, and traverses floodplain for short distances to the north and south of the river.

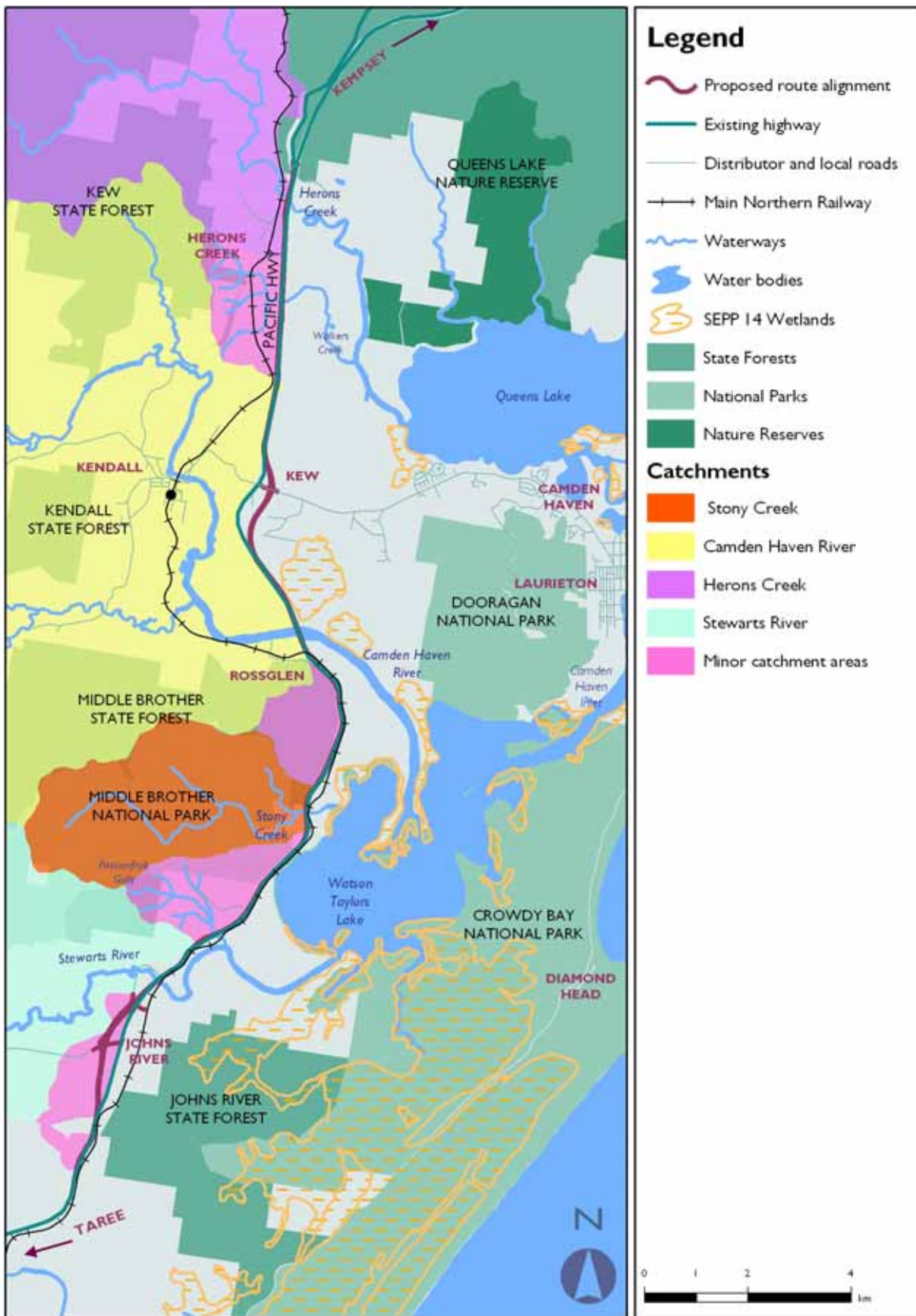


Figure 9-1 Surface hydrology and catchment areas

Hérons Creek

The existing highway crosses Herons Creek near the settlement of Herons Creek, approximately 6 km upstream from Queens Lake. Herons Creek has a catchment area of 59.3 km². There are two waterway channels that are bridged where the existing highway crosses Herons Creek, the main creek crossing adjacent to the Herons Creek Public School and a floodway (which is normally dry) about 100 m to the south.

Watson Taylors Lake

Watson Taylors Lake has a surface area of approximately 11.9 km² and is located to the east of, and in parts adjacent to, the Main Northern Railway line and Pacific Highway. The major inflows are the Stewarts River, Camden Haven River and Stony Creek, which flow into the Lake from the west. Watson Taylors Lake is part of Crowdy Bay National Park, and bordered by Dooragan National Park and SEPP 14 wetlands, the boundaries of which are shown on Figure 9-1. It drains in a northeast direction to the Camden Haven Inlet and ultimately to the Pacific Ocean.

Queens Lake

Queens Lake is located approximately 2.5 km to the east of the highway between Kew and Herons Creek. It receives water from the Herons Creek catchment and other tributaries from Queens Lake Nature Reserve to the north and minor tributaries from the south. Queens Lake has a surface area of approximately 11.3 km².

Minor watercourses

In addition to the three major catchments, the existing highway crosses three watercourses draining medium sized catchments with areas between 2 km² and 50 km²:

- Passionfruit Gully has a catchment area of 2.2 km² to the west of the highway crossing.
- Stony Creek has a catchment area of 12 km² to the west of the highway crossing. The catchment of Stony Creek above the highway is short and steep and located almost entirely within Middle Brother National Park and State Forest. Stony Creek flows into Watson Taylors Lake approximately 0.8 km to the east of the highway.
- Walkers Creek has a catchment area of 3 km² to the west of the highway crossing.

There are numerous other small, unnamed catchments of less than 2 km² in the area crossed by the Proposal (see Working Papers Nos 2 and 4). Where the existing highway crosses a minor watercourse, an existing culvert allows passage of the water through the highway embankment, though in some instances it is undersized. Where the culvert is undersized, the drainage cross-flow of water is impeded by the highway and provision has been made as part of the Proposal for replacing or augmenting the existing culvert. The location and areas of these minor watercourses, as well as any waterway structures (such as culverts) at the highway crossing, are detailed in Working Paper No. 2. Proposed waterway openings at each watercourse are also summarised in Section 6.7.

SEPP 14 wetlands

SEPP 14 wetlands No. 544a (Sunnyvale Swamp) and No. 544c (Kew Swamp) are located immediately to the east of the Proposal (see Chapter 11). SEPP 14 wetlands are also located to the east of the existing highway, bordering Watson Taylors Lake at the locations where Camden Haven River, Stony Creek and Stewarts River discharge to the lake. During periods of high rainfall, these rivers, and in particular the Camden Haven River, would flood the SEPP 14 wetlands within their floodplains (see Chapter 11).

9.1.2 Surface Water Quality

9.1.2.1 Surface water quality monitoring program

A program of water quality sampling and analysis for waterways traversed by the Proposal was undertaken to characterise the existing baseline water quality of key waterways in the study area. The water quality sampling locations were selected in order to provide adequate representation of those that which could potentially be affected during construction activities (see Figure 9-2). Water samples were collected on six occasions (two wet and four dry weather sampling periods) between February 2001 and March 2002. An additional sampling run was carried out in January 2003 to collect samples from a creek near Cluleys Road. Table 9-1 indicates sampling dates and weather conditions at the time.

Table 9-1 Water quality sampling program

Sample date	Weather conditions
23 February 2001	Wet weather
18 June 2001	Dry weather
22 August 2001	Dry weather
13 December 2001	Dry weather
6 February 2002	Wet weather
12 March 2002	Dry weather
22 January 2003*	Wet weather

* Samples only collected from creekline near Cluleys Road

Figure 9-2 shows the location of water quality monitoring points along the Proposal route. Samples were collected from the following locations:

- Herons Creek upstream and downstream of the highway (locations 1 and 2)
- Camden Haven River upstream and downstream of the highway (locations 3 and 5 respectively, location 4 is a duplicate of location 3)
- Stony Creek upstream and downstream of the highway (locations 6 and 7)
- Watson Taylors Lake (location 8)
- Passionfruit Gully upstream of the highway (location 9)
- Stewarts River upstream and downstream of the highway (locations 10 and 11)
- Passionfruit Gully downstream of the highway (location 12)
- the creekline near Cluleys Road in January 2003 upstream and downstream of the highway (locations 13 and 14).

9.1.2.2 Monitoring results

Table 9-2 presents a summary of the results from the water quality monitoring.

Water quality results have been compared to the ANZECC 2000 water quality guidelines for aquatic ecosystems (the Guidelines) where available. Where ANZECC 2000 does not include guidelines for a particular parameter, ANZECC 1992 or NSW DEC guidance was sought.

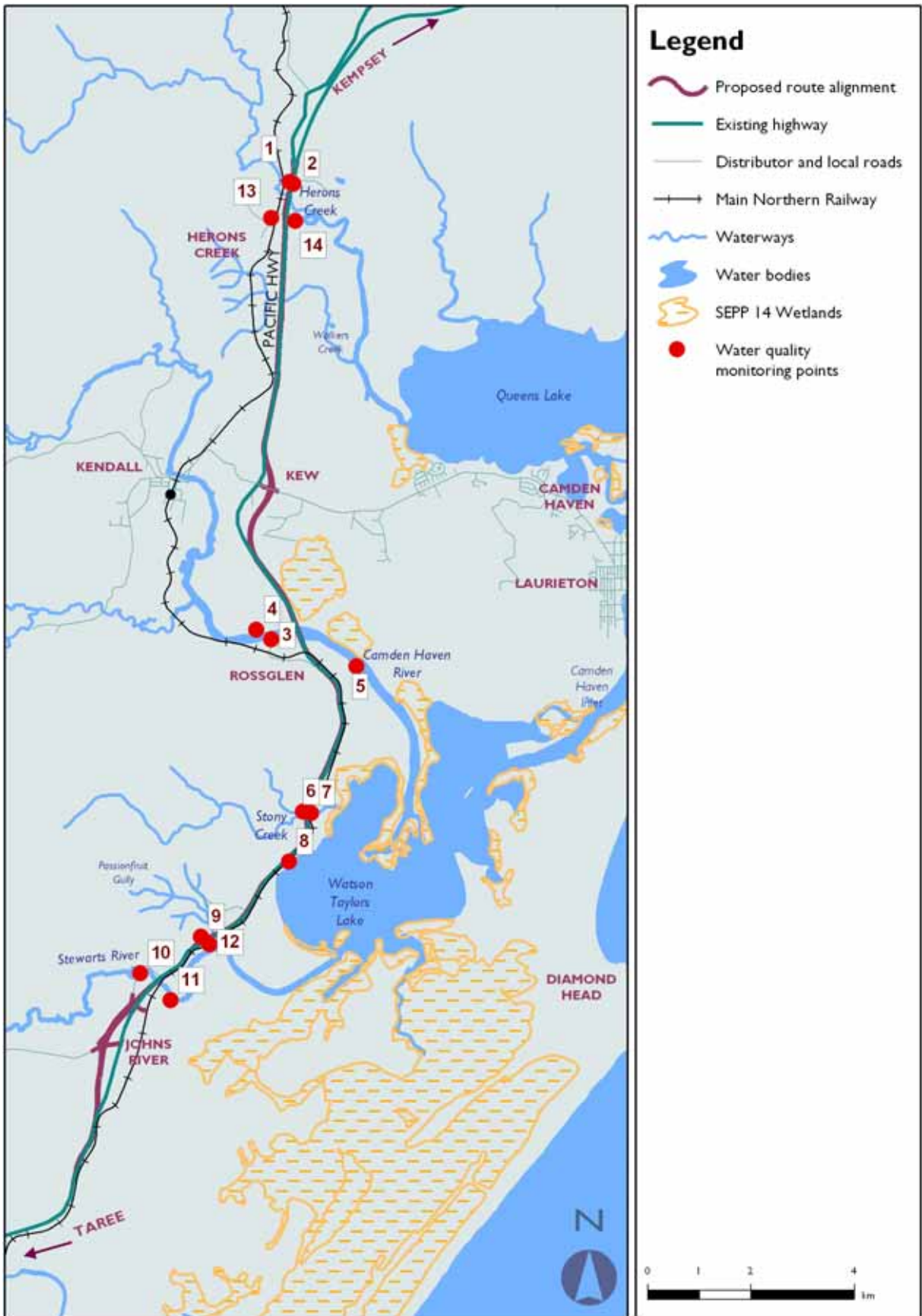


Figure 9-2 Water quality monitoring points

Dissolved oxygen

Levels of dissolved oxygen (DO) were high and generally within the Guidelines during the summer wet weather periods (February 2001 and February 2002). During each dry weather sampling run, DO levels were recorded well below the Guideline. During summer dry conditions (December 2001 and March 2002), DO levels recorded at all sites were below the Guideline lower limit of 80%. During winter dry conditions, DO levels in Stewarts River were significantly lower than the Guideline, whilst DO levels at the other sites were reasonable. DO levels are sensitive to many factors including stream mixing; respiration and photosynthesis by in-channel organisms; and flow variations. These factors are dependent on the time of day and rainfall events.

Salinity and conductivity

In February 2001 (summer wet conditions), conductivity and salinity levels indicate that Watson Taylors Lake could be classified as marine waters (tidal waters typically have a salinity of > 30,000ppm), whilst the conductivity and salinity recorded at all other sites is typical of lowland rivers. ANZECC 2000 sets out a conductivity range between 125 and 2,200 $\mu\text{S}/\text{cm}$ for lowland rivers in South-Eastern Australia. During the second summer wet sampling period (February 2002), Watson Taylors Lake and Camden Haven River were both classified as marine waters based on the salinity and conductivity results. In June and August 2001 (winter dry conditions), and December 2001 and March 2002 (summer dry conditions), the Camden Haven River, Watson Taylors Lake and Stewarts River all displayed high conductivity and salinity levels characteristic of marine waters. During the August 2001 sampling period, conductivity levels reached a hyper saline level of 60,200 $\mu\text{S}/\text{cm}$, significantly higher than an expected conductivity of up to approximately 50,000 $\mu\text{S}/\text{cm}$, which typifies seawaters.

pH

pH was lower than the Guideline lower limit for lowland rivers at all sites during February 2001 (summer wet period), and at all sites with the exception of Herons Creek and Watson Taylors Lake (locations 1, 2 and 8) during February 2002 (summer wet period).

Total Phosphorus

Concentrations of total phosphorus (TP) exceeded the Guideline in December 2001, February 2002, March 2002 and January 2003.

In December 2001 and March 2002, only water samples collected from Herons Creek, Stony Creek and Passionfruit Gully were analysed for TP, and the reported concentration in samples from Herons Creek and Passionfruit Gully exceeded the Guideline limit. In February 2002, water samples collected from Herons Creek, Passionfruit Gully, Stony Creek and Stewarts River all exceeded the Guideline by a factor of about 10 or more. The TP concentration recorded in samples collected from Cluleys Road Creek in January 2003 also exceeded the Guideline by a factor of about 10 or more.

It was found that there was no particular correlation between the concentrations of TP recorded in the samples and whether they were collected upstream or downstream of the highway. On some occasions the concentration of TP was notably higher on the upstream side of the highway and thus it appears that the existing highway is not a significant contributor of TP to the surface watercourses. Whilst the data is not extensive enough to enable a determination of the major contributor of TP in the surface watercourses, it is likely that agricultural activities (i.e. use of fertilisers) in the catchments are contributors to TP concentrations. It is unclear as to why the levels of TP were all below detection limits in the first three sampling runs, which covered both wet and dry periods, whilst concentrations significantly exceeded the Guidelines in the following three sampling runs. Additional investigations would be required to determine the source of elevated TP in the surface watercourses and understand the characteristics of the baseline concentrations.

Table 9-2 Water quality – test results

Parameter	EQL ⁽¹⁾	Sample locations														Guideline/ trigger values
		1	2	3	4	5	6	7	8	9	10	11	12	13 ⁽¹²⁾	14 ⁽¹²⁾	
Temp (°C)	-	9.71-21.34	9.78-21.36	13.30-24.00	17.45-24.00	15.06-24.00	12.00-20.70	11.90-21.75	14.1-27.11	14.22-21.47	14.00-25.00	16.10-26.80	11.80-21.37			<2% increase
Dissolved Oxygen (% saturation)	-	8.5-103	25-116	45-165	45-74.3	45.6-177	14.8-124	30.5-130	68.2-200	9.6-157	9.7-113	8.7-124	14.8-85.9	13.7	2.9	85-110 ⁽³⁾ 80-110 ⁽⁴⁾
Conductivity (EC, Salinity) (µS/cm)	-	55-195	91-195	323-52500	9800-36500	411-51800	14-465	133-18400	10550-60200	158-471	101-55700	126-54800	101-394	445	390	125 - 2200 ^(3, 8, 11)
Salinity (ppm)	-	<0.06-160	<0.06-162	4.29-34400	4.29-23000	5.54-33900	<0.06-230	<0.06-150	22.28-40300	<0.06-240	<0.06-36900	<0.06-36400	<0.06-190			1000 ⁽⁹⁾
pH	-	5.81-7.3	5.84-7.41	6-7.76	6-7.76	6.23-7.63	6.03-7.5	5.91-7.1	6.7-8.05	6.08-8.14	5.97-7.2	6.04-7.25	5.9-7.43	3.94	4.33	6.5 - 8.0 ⁽³⁾ 7.0-8.5 ⁽⁴⁾
Turbidity (ntu)	0.1	4.3-74.4	4.2-75.7	2.3-41	4.5-41	0-38.7	0-6.8	0-6.9	7.2-486	1.7-28.5	6.8-183.6	0-112	3.1-72	600	108	6-50 ⁽³⁾ 0.5-10 ⁽⁴⁾
Iron (mg/l)	0.01	0.5-4.4	0.5-3.1	0.02-0.52	0.02-0.52	<EQL-0.8	0.06-0.25	0.05-0.6	<EQL-1.6	0.2-8.5	0.09-1.3	0.01-1.1	0.24-2.5	3.8 – 4.2	1.7	No guideline
Aluminium (mg/l)	0.1	<EQL-0.15	<EQL-0.15	<EQL-0.19	<EQL-0.2	<EQL-0.25	<EQL-0.1	<EQL-0.1	<EQL-0.35	<EQL-0.07	<EQL-0.12	<EQL-0.13	<EQL	0.71	0.12	0.05 for pH>6.5 ⁽⁵⁾ No guideline for pH <6.5
Cadmium (mg/l)	0.0002	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	0.0004 - 0.0013	0.0002	0.0002 ⁽⁵⁾ 0.0007 ⁽⁷⁾
Lead (mg/l)	0.001	<EQL- 0.001	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	0.002 - 0.003	<EQL	0.0034 ⁽⁵⁾ 0.0044 ⁽⁶⁾
Total Phosphorus (mg/l)	0.1	<EQL- 0.29	<EQL-0.21	<EQL ⁽¹³⁾	<EQL	<EQL	<EQL- 0.13	<EQL- 0.11	<EQL ⁽¹³⁾	<EQL- 0.3	<EQL- 0.22	<EQL- 0.23	<EQL-0.32	1.1 - 1.4	0.56	0.05 ⁽³⁾ 0.025-0.030 ⁽⁴⁾
Reactive Phosphorus (mg/l)	0.01		0.01						<EQL							0.02 ⁽³⁾ 0.005-0.010 ⁽⁴⁾
Oil and grease ⁽¹⁰⁾ (mg/l)	5	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	<EQL	11 – 15	15	ns ⁽²⁾

Notes:

The values presented above represent the maximum and minimum values recorded during the six water quality sampling runs conducted between February 2001 and March 2002.

1. EQL: Estimated Quantification Limit (specified by laboratory)
2. ns: not specified for oil and grease. Contaminated Sites: Guidelines for Assessing Service Station Sites (NSW DIPNR 2004). Information needed to select threshold concentrations is incomplete. The POEO Act 1997 and Clean Waters Regulations 1972 prohibit the pollution of waters by unlicensed contaminated discharges and require licensed discharges to be visually free of oil and grease. Experience has demonstrated that the latter criterion is equivalent to an oil and grease concentration of approximately 10 mg/L.
3. ANZECC 2000 - Aquatic Ecosystems: Lowland River – trigger values
4. ANZECC 2000 - Aquatic Ecosystems: Estuarine and Marine – trigger values
5. ANZECC 2000 - Trigger value for toxicants in freshwater for 95% protection of species
6. ANZECC 2000 - Trigger value for toxicants in marine waters for 95% protection of species
7. ANZECC 2000 - Trigger value for toxicants in marine waters for 99% protection of species
8. NSW coastal rivers are typically in the range 200-300 µS/cm⁻¹ (ANZECC 2000)
9. ANZECC 1992. Note however, that tidal areas are typically >30,000 ppm
10. Oil and grease analysed in samples collected on 23 February 2001 and January 2003 only.
11. ANZECC 2000 does not provide salinity/conductivity guidelines for estuarine or marine waters. Values of conductivity up to 50,000µS/cm may be expected for seawater.
12. Samples collected at Sites 13 and 14 on 29 January 2003 only. Values represent single round of sampling.
13. One sample date.

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It should also be noted that the analytical Estimated Quantification Limit (EQL) as advised by the testing laboratory (i.e. the level shown in Column 2 of Table 9–2 which quantification was not possible) is higher than the Guideline trigger value for TP. Thus, even where results are reported as <EQL, it is possible that the concentration of TP could still exceed the guideline.

Metals

Concentrations of aluminium (Al) were detected above the EQL only in the samples collected on 23 February 2001 for locations 1 to 12. However, of all these sites on this date, only location 8 (Watson Taylors Lake) had a pH greater than 6.5. Therefore the sample at location 8 on 23 February 2001 was the only occasion when the concentration of Al exceeded the Guidelines.

Turbidity

In general, the turbidity of the samples was within the Guideline at all locations. However, in the February 2002 sampling run, the turbidity in Herons Creek, Watson Taylors Lake, and Stewarts River significantly exceeded the Guideline. February 2002 was a wet weather occasion following a period of dry, which indicates that the exceptionally high turbidity was caused by the transport of sediment and other matter into surface watercourses in surface runoff. Similarly, the exceptionally high turbidity recorded at sites 13 and 14 coincided with a period of wet weather in January 2003. The results indicate that during dry weather, turbidity in the surface watercourses is generally within the Guideline, however during wet weather the turbidity level can exceed the Guideline by a significant amount.

Sites 13 and 14

At locations 13 and 14, sampled in January 2003, DO levels recorded were very low (13.7% and 2.9% respectively) and pH was significantly below the Guideline lower limit for lowland river aquatic ecosystems. Cadmium concentrations recorded at Sites 13 and 14 were above the Guideline limits. Dissolved metal recorded in the wetland upstream of the highway may be due to the low pH and low flow rates through this system. Concentrations of oil and grease were above the NSW DEC guideline of 10 mg/l, indicating the potential for contaminants present in petrol to be present at the site.

9.1.2.3 Further monitoring

Requirements for further monitoring during construction are described in Section 9.4.

9.1.3 Existing flooding characteristics

The Proposal route crosses the floodplains of three major waterways - Stewarts River, Camden Haven River and Herons Creek.

Table 9–3 summarises the predicted flood levels for these waterways at the locations of the highway crossings on the floodplain for the existing highway. The effects of the Proposal on flooding at the three main waterway crossings, as well as on afflux (difference in flood level between the upstream and downstream sides of a bridge crossing) and flow velocities, are described in Section 9.2.2.5.

Stewarts River

The flooding behaviour of the Stewarts River has been predicted by basic hydraulic modelling. The existing bridge crossing at Stewarts River has a minimum road level of 8.5 m AHD, which is well above the predicted 100 year Average Recurrence Interval (ARI) peak flood level of 3.4 m AHD at this location. South of the bridge in the township of Johns River the minimum existing road level is about 5 m AHD, still appreciably above the predicted 100 year ARI peak flood level.

Table 9-3 Predicted flood levels for the existing highway

Watercourse and location	Minimum elevation of the existing highway centreline (m AHD)	Predicted peak flood levels at the existing highway crossing (m AHD)			
		5 year ARI ⁽¹⁾ flood event	20 year ARI ⁽¹⁾ flood event	100 year ARI ⁽¹⁾ flood event	PMF ⁽²⁾
Stewarts River - at bridge crossing	8.4 (min existing road level to south of bridge 6.0 approx)	2.60	2.94	3.40	4.72
Camden Haven River – at bridge crossing	6.62 (Station 12740)	2.85	3.37	3.96	6.91
Camden Haven River floodplain- 500 m north of bridge crossing	4.3	-	-	approx 4.20	-
Camden Haven River floodplain – 1k m south of bridge	3.55	-	-	3.8	-
Herons Creek	7.05	5.72	6.28	6.70	8.35
Herons Creek floodplain – south of bridges	6.20 (Station 21280)	-	-	6.97	-

Source: Working Paper No. 4

Notes: 1 ARI - Average Recurrence Interval.

2 PMF - The Probable Maximum Flood is the most severe flood considered possible by hydrologists.

Camden Haven River

Based on hydraulic modelling of the 100 year ARI flood event, the existing highway would be overtopped during a 100 year ARI event approximately 500 m north of the bridge across the Camden Haven River. The maximum overtopping depth and velocity during the 100 year ARI event are predicted to be 0.3 m and 1.5 m/s respectively. The peak flood level on the upstream side of the highway at this location would be about 4.2 m AHD. The minimum centreline elevation of the existing highway at this location is approximately 4.3 m AHD at Station 13320. The existing highway would not be overtopped during the predicted 20 year ARI event.

The hydraulic modelling at this location included estimation of peak velocities (depth and width averaged) for the 100 and 20 year ARI flood events. Predicted peak velocities were 2.2 m/s and 1.8 m/s respectively in the Camden Haven River under the existing bridge.

The afflux, or difference between upstream and downstream levels resulting from the existing highway and bridge, in a peak 100 year ARI flood event is about 300 mm at the point where overtopping occurs and about 40 mm at the bridge itself.

Figure 9-3 shows the predicted 100 year ARI flood levels at the Camden Haven River for the existing highway.

A number of houses upstream and downstream of the existing highway are located within areas affected by the 20 year and 100 year ARI events.

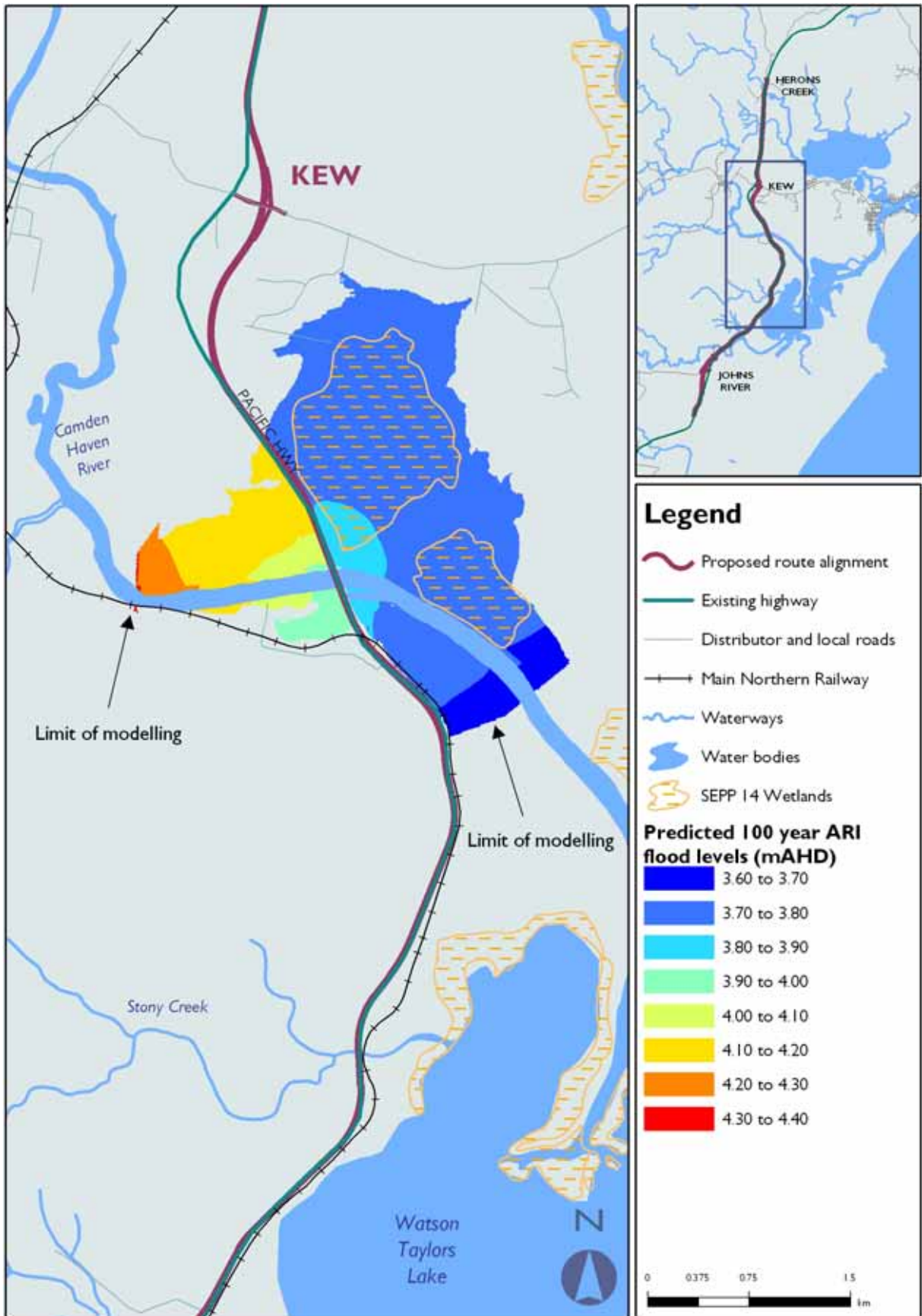


Figure 9-3 Camden Haven River - predicted 100 year ARI flood levels

Herons Creek

Hydraulic modelling of the existing highway predicts that during a 100 year ARI flood event a 170 m section of the highway south of the two existing Herons Creek bridges would be overtopped, with the depth of water at the lowest point of the highway reaching approximately 1.0 m. The peak 100 year ARI flood level difference upstream and downstream (afflux) of the main (northern) bridge across Herons Creek is approximately 0.57 m. The existing afflux at the southern floodway channel is approximately 0.75 m. The maximum peak flood level difference upstream and downstream of the highway occurs within the section of overtopping, and is predicted to be approximately 2.0 m during the 100 year ARI flood event. The peak overtopping velocity in this event would be approximately 2.7 m/s.

The peak velocities during the 100 year ARI event in the main channel of Herons Creek under the existing bridge would be 2.1 m/s at the banks and 2.0 m/s in the centre of the creek, while in the floodway channel the peak velocities would be 1.6 m/s at the banks and 3.0 m/s in the centre.

Figure 9-4 shows the predicted flood levels for the 100 year ARI event for the Herons Creek for the existing highway.

9.2 Assessment of effects

The specific characteristics of the study area traversed by the Proposal necessitate consideration of the impacts of the Proposal during both construction and operation, and provision of adequate mitigation measures to protect water quality and aquatic biota. These characteristics are its low-lying nature in places and susceptibility to flooding, the sensitivity of downstream areas including SEPP 14 wetlands and National Parks, areas of Acid Sulfate Soils (ASS) and Potential Acid Sulfate Soils (PASS) and important commercial and recreational fisheries.

The Proposal crosses three major waterways (Stewarts River, Camden Haven River and Herons Creek) and several minor waterways and, therefore, considerable and appropriate water quality treatment measures would be required to contain and treat surface water runoff.

9.2.1 Construction impacts

Construction of the Proposal would result in considerable disturbance to soils. The disturbance and exposure of soils, in particular within or immediately adjacent to waterways and drainage lines and on floodplains, is the principal environmental risk to the integrity of the local water environment. During periods of rainfall, sediment 'wash-out' from exposed areas would be exacerbated and sediment-laden runoff and associated pollutants could enter downstream waterways, adversely affecting water quality and aquatic biota.

9.2.1.1 Surface water quality

Surface waters at the greatest risk of pollution are those situated closest to the potential pollution source (the Proposal), especially those where construction activities are proposed to take place within the channels or direct flush zones feeding local waterways. Potentially polluting activities associated with construction of the Proposal include earthworks, fuel and chemical storage, refuelling, disposal of wastewater, placement of concrete, staff facilities, waste collection and disposal procedures, plant and wheel washing, and erosion from exposed ground and stockpiles.

Construction compounds can be a potential source of water pollution as this is where fuel and chemicals would be stored, vehicles would be parked and maintenance works would be carried out. Appropriate measures as described in Section 9.3 regarding the siting of compounds and provision of bunding for the containment of any spillages are necessary to ensure that any accidental spillages are unlikely to lead to deterioration in the quality of surface water and associated ecological damage.

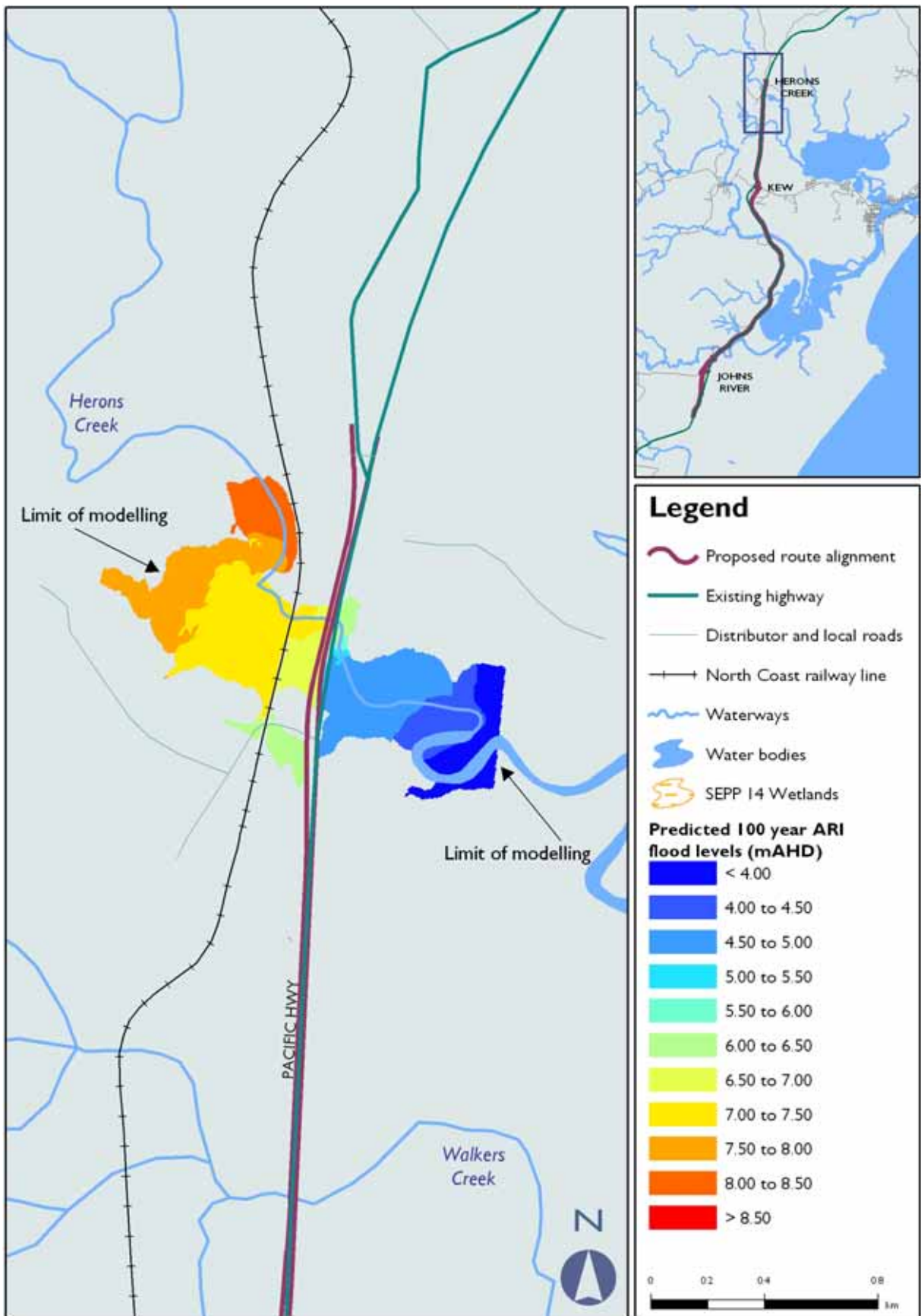


Figure 9-4 Herons Creek - predicted 100 year ARI flood levels

The influx of sediment laden runoff from disturbed and exposed areas of ground into local waterways could have a detrimental impact on water quality and therefore on aquatic ecology, both in the vicinity of construction areas and further downstream. Soil erosion may occur wherever overland flows are artificially concentrated or obstructed, especially in areas where soil is disturbed. The temporary works associated with construction activities may reduce the hydraulic capacity of any waterways crossed, due to constrictions. This may increase sediment deposition upstream and cause erosion immediately downstream of crossing points. Furthermore, erosion may occur within the diversion/catch drains during rainfall events, if the design and slope of the drains results in scouring due to excessive flow velocities for the type of drain/lining chosen.

Sediment would be generated during the earthworks, particularly by vehicles tracking over disturbed areas of ground, excavating into the soil or possibly due to suspended sediment generated from the temporary dewatering of excavations. Exposed soils within stockpiles would be susceptible to 'wash-out' during periods of rainfall, if appropriate mitigation measures are not provided.

Mitigation measures for the control of erosion and sedimentation during construction are described in Section 9.3, including the provision of 42 sedimentation basins during the construction phase.

The potential contamination of surface waters as a result of disturbing and exposing areas of PASS during construction works is discussed in Chapter 8.

9.2.1.2 Groundwater quality

Local private groundwater bores (see Chapter 8) may be exposed to risk of impact from accidental spillages of fuels, oils and chemical agents. Such pollutants may infiltrate to the groundwater and adversely affect the water quality of bores.

The vulnerability of the groundwater to pollution (i.e. accidental spillage) is dependent upon the extent and permeability of the overlying strata separating any potential spillage and the water table, and the proximity of a potential spillage to a groundwater source. The soils overlying the water table along the Proposal route have a high clay content and are of low permeability (see Chapter 8). It is therefore considered that the potential risk of contamination of groundwater from the infiltration of pollutants through overlaying clay soils during construction would be low.

At the river crossings, the bridge piles would be installed below the level of the water table. The water table is very close to the surface at the Stewarts River, Camden Haven River and Herons Creek crossings. Groundwater at these locations is therefore at risk of contamination from accidental spillages and disturbance of ASS generating acid leachates during construction (refer to Chapter 8).

The nearest groundwater bores to the Stewarts River, Camden Haven River and Herons Creek crossings are as follows:

- Stewarts River crossing – around 1 km to the southwest (one bore) and 1 km to the north-east and north-west (two bores)
- Camden Haven River crossing – around 2 km to the southeast and northeast (one bore at each locality)
- Herons Creek crossing – around 0.5 km to the northeast and 1.5 km to the southeast (one bore at each locality).

Given the low yields of groundwater bores in the area and the significant distance of the bores from these waterways, the Proposal is unlikely to adversely impact on these bores (refer to Figure 8-4 in Chapter 8).

Major cuttings required for the Proposal construction, in particular at Station 1400 to 1710 on the Johns River bypass (14 m) and at Ocean Drive between Station 14600 and 50000 (18 m) would not intercept the water table. Any potential 'draw-down' effects at the locations of cuttings are likely to be associated with very shallow or perched water tables within residual soils. Impacts are therefore expected to be localised (not expected to extend more than 10 m away from the cutting).

9.2.1.3 Flood risk and alteration of natural drainage patterns

There may be local increases in runoff volumes and rates due to temporary changes in land use during construction (e.g. construction of haul roads) and minor alterations to overland flow paths. It is also acknowledged that some construction activities would take place within and adjacent to watercourses, and that waterway obstructions could occur during construction. However, any significant obstructions would only be temporary, and their nature would result in localised flooding only. The risk of inundation of the highway would be low.

There are a number of transverse drainage structures (culverts and pipes) that facilitate flows under the existing highway. Modification or replacement of these structures may require temporary obstruction of the waterway, possibly resulting in minor localised flooding on the western side of the highway if the obstructions coincided with high rainfall events. This impact would be temporary in duration and of minor significance.

9.2.2 Operational impacts

During the operation of the Proposal, the local water environment would be susceptible to potential impacts due to:

- increased rate and volume of highway runoff associated with the introduction of additional impervious surfaces
- increased flood risk due to the introduction of additional permanent physical obstructions in waterways (bridge piers) and floodplains (widening of embankments on the approaches to bridges)
- pollution of waterways from highway runoff and accidental spillages
- increased risk of erosion or flooding due to minor alteration of natural drainage patterns.

9.2.2.1 Surface water quality

There is the potential for pollution of local waterways during operation of the Proposal from the mobilisation and transport of contaminants (particulate and dissolved) in the highway runoff. Principal pollutants that are likely to be present in highway runoff include:

- sediments from embankments, road surface wear and grit, rubber from tyres
- hydrocarbons from vehicle emissions
- heavy metals such as cadmium and lead that attach to particles mobilized from the highway surface
- nutrients mobilized from roadside verges
- pesticides and herbicides from roadside verge maintenance
- litter
- accidental chemical spillages.

Highway runoff would discharge over fill batters as overland sheet flow into toe drains or swales or where possible onto undisturbed land (i.e. overland filtration). This overland filtration strategy has been adopted to avoid concentrating flows. Where this is not possible (e.g. in areas of cut or where the general topography does not allow) or in locations where there are sensitive downstream aquatic habitats, runoff would be directed to a series of permanent water quality control ponds. In areas where the availability of land is limited adjacent to the highway, the ponds would be in the form of longitudinal basins.

Section 9.3 describes the 23 permanent water quality control ponds proposed for the control of water quality during operation of the highway upgrade.

The water quality control basins have been designed in accordance with *Managing Urban Stormwater: Soils and Construction 'Blue Book'* (Landcom 2004), which recommends that the 75th percentile five-day rainfall event should be adopted as the design rainfall event for the sizing of sedimentation basins. The potential therefore exists for pollutants from highway runoff retained within the ponds to flow into local waterways during storm conditions which exceed the design event (i.e. the 75th percentile 5 day rainfall event) either due to increased rates and volumes of highway runoff resulting in stormwater levels within the ponds overtopping, or by inundation of the ponds located within floodplains. In these events, pollutants (dissolved and particulate) could be mobilised and enter adjacent waterways. The impact on the water quality of the waterways would be dependent on the amount of pollutant present that might be mobilized, the volume and rate of flow in the waterway; capacity of the waterway to assimilate pollutant loads; and the resultant dilution of pollutants. These impacts are likely to be greater in minor creeks and drainage lines traversed by the Proposal. For a waterway the size of the Camden Haven River, it is considered that the volume and rate of flow during an inundation of a pond would significantly dilute the concentration of any mobilised pollutants.

Two SEPP 14 wetlands, No. 544a and No. 544c, are located on the eastern side of the existing highway immediately north of the Camden Haven River crossing. An embankment from a section of the former highway runs parallel to the highway, extending from Station 12800 to the edge of the Camden Haven River floodplain at Station 13500, and separates the existing highway from these SEPP 14 wetlands. While this embankment does act as a physical barrier to highway runoff from the existing highway, gaps and culverts occur along the old embankment at Station 13040, Station 13100 and Station 13200. These facilitate cross-flow drainage from the existing highway to the SEPP 14 wetlands. Given the eastern edge of the batters of the proposed highway upgrade would be within 70 m of SEPP14 wetlands at Station 13100, tapering to within 28 m at Station 13500, the construction phase sedimentation basin proposed on the eastern side of the Proposal at Station 13100 would be retained as a permanent water quality control pond. This pond would be approximately 318 m³ in size and is designed to provide primary containment for highway runoff in order to minimise the potential for any adverse impacts on the two SEPP 14 wetlands. Further details are provided in Section 9.3.3.

9.2.2.2 Erosion and sedimentation

There is the potential for sedimentation of local waterways due to scouring processes associated with artificially concentrated flows. This may occur at the locations of permanent obstructions within the watercourses and their floodplains or where drainage flows are altered following the upgrade works.

Drainage

There is the potential for scouring and consequent sedimentation to occur at the inlet and/or outlet of the culvert structures during high rainfall/flow events, particularly where they have been upgraded to increase flow capacities (e.g. the proposed culvert upgrade south of the floodway channel of Herons Creek). Scour protection measures would be developed during the detail design phase of the project, as described in Section 9.3.3.

Bridges

Five bridges would be constructed across the three main watercourses described in Section 9.1.1. The five bridges comprise new bridges parallel to the existing bridges at Stewarts River, Camden Haven River and at the Herons Creek floodway, plus two new parallel bridges across the main channel at Herons Creek (see Section 6.5.1). Since these structures would be located within the channels and/or floodplains of the major rivers, the structures have the potential to cause erosion and sedimentation.

Of the five structures however, the Camden Haven River crossing would be the only watercourse where piers would be located within the waterway itself, due to the significant width of permanent water present. There would be no piers or abutments proposed within the waterways at the other bridges. At all locations, including the Camden Haven crossing, the proposed bridge would duplicate and/or replace the existing bridge structure, maintaining span lengths generally identical to that existing, and with pier and abutment arrangements also replicating those existing. Thus the bridge proposals would have no impact or very little impact on the cross sectional area of the river channels and it is considered that there would be minimal if any additional constriction to flow at these locations.

The watercourse with the greatest potential for an increase in peak velocities would be the Herons Creek and associated floodway crossings since the highway level would be raised in this area to provide protection from 100 year ARI predicted flood level. The peak velocities of flow in Herons Creek through the existing highway bridge during the 100 year ARI flood event are estimated by hydraulic modelling (see Working Paper No. 4) as 1.7 m/s, 2.0 m/s and 2.1 m/s on the left bank, centre and right bank of the creek respectively. After allowing for the effects of the proposed new culvert 200 m south of the floodway bridge, modelling predicts similar peak velocities in Herons Creek and the southern flood channel following the proposed upgrade. Thus, whilst it is not considered that the proposals would increase the risk of scour in Herons Creek and the floodway channel, scour protection measures may be required and these would be determined in the detail design phase as described in Section 9.3.3.

Similarly, hydraulic modelling predicts that there would be no increase in peak velocities of flow in the Camden Haven and Stewarts Rivers under the bridge following the construction of the Proposal. It is therefore considered that the increased risk of scour as a result of the Proposal is negligible.

Twin bridges are also proposed at the crossing of the smaller watercourse at Stony Creek, where the existing bridge would be replaced. Site investigations showed evidence of local scour at the existing bridge. It is likely that localised scour protection measures would be required, and these would be determined in the detail design phase as described in Section 9.3.3.

9.2.2.3 Groundwater quality

The water table is situated near to the surface in the locations adjacent to the waterways (i.e. Stewarts River, Camden Haven River and Herons Creek crossings). Groundwater would be susceptible to pollution from highway runoff in the locations of the water quality control ponds adjacent to these waterways due to a possible direct flow path between the potentially pollutant-loaded highway runoff and the groundwater. Most of the pollutants in the highway runoff are likely to be less dense than water and it is considered that these would be trapped at the surface within the pond and thus not likely to enter the groundwater. In addition, the bases of water quality control ponds tend to seal over time and become less permeable, limiting the transfer of pollutants. It is unlikely that the Proposal would adversely impact on groundwater during its operation.

9.2.2.4 Alteration of natural drainage patterns

Existing cross-flow drainage patterns along the Proposal route would generally be maintained by the installation of new or upgraded existing culverts. As a general drainage design principle, runoff would not be moved from one catchment to another. Where possible, runoff from the road surface would discharge as overland sheet flow using the overland filtration strategy (see Section 9.2.2.1), and at other locations where water quality control ponds are provided, runoff captured from the road surface would be directed to the pond prior to discharging into the local waterways. The use of ponds and revegetation programs is intended to assist in preventing natural hydrologic regimes being adversely affected by the Proposal.

The existing culvert located approximately 200 m to the north of the Camden Haven River is sunken, however there is still capacity for water to flow through it. During periods of high flow in the Camden Haven River the culvert flows from west to east but during high rainfall events on the SEPP 14 wetland located on the east side of the highway, the natural drainage pathway for this water is from east to west through the culvert. However, a bund unrelated to the highway has been constructed on private land to the west of the highway. It prevents the continuation of this natural flow path and has created an area of ponding and swampland between the highway and the bund. As part of the Proposal this culvert would be replaced with twin box culverts that would increase its current flow capacity, and to create a grassed open drainage line southward along the toe of the batter on the west side of the new northbound carriageway. The open drain would extend from the culvert opening to the water quality control pond located on the north bank of the Camden Haven River. This would help to restore the natural drainage in this location. The outlet from this water quality control pond could be piped to the existing outlet drain under Sunnyvale Road on the east side of the highway. This drain has a gated outlet that prevents tidal inflows into the SEPP 14 wetlands. Alternatively a new gated outlet could be constructed under Sunnyvale Road on the west side of the highway. Arrangements would be discussed and agreed with Hastings Council during the detailed design phase.

9.2.2.5 Flood risk

The NSW Government's *Floodplain Development Manual* (NSW Government 2001) supports the NSW Government's Flood Prone Land Policy. The primary objective of the policy is 'to reduce the impact of flooding and flood liability on individual owners and occupiers of flood-prone property, and to reduce private and public losses resulting from floods, utilising ecologically positive methods wherever possible'.

The north-south aligned Pacific Highway crosses perpendicular to the natural flood flow paths, which flow predominantly eastwards. The highway has the potential to impede flood flows in the watercourses and their floodplains. The following assessment of potential flood risk due to operation of the Proposal is based on the detailed hydraulic analysis included as Working Paper No. 4.

The following design criteria are to be fulfilled by the Proposal:

- one lane is to be trafficable in each direction for the 20 year ARI flood event south of Kew
- one lane is to be trafficable in each direction for the 100 year ARI flood event north of Kew
- the Proposal is to cause no unacceptable increase in flood levels, velocities or time of flood inundation.

Stewarts River

The estimated peak 100 year ARI water level in the Stewarts River at the location of the existing Pacific Highway bridge is approximately 3.4 m AHD (see Table 9–3).

The bridge deck, piers and abutment for the Proposal across the Stewarts River are similar to those of the existing bridge. The width of the flow opening area of the existing bridge is approximately 290 m, which is adequate for the floodwater not to experience any appreciable constriction. Hydraulic modelling of the proposed bridge duplication showed that there would be a negligible impact on peak flood levels, afflux, velocities and time of inundation for the Stewarts River floodplain.

Thus, with the existing and proposed bridge deck levels at approximately 8.5 m AHD, and the minimum highway level to the south at 6.2 m AHD, it is considered that the Proposal would be above the estimated peak 100 year ARI flood level and that there would be a negligible impact on flooding in the vicinity of Stewarts River.

These results are summarised in Table 9-4.

Table 9-4 Stewarts River flood summary

	Main channel
Predicted 100 year flood level (m AHD) immediately upstream of highway	3.4 (with upgrade)
Minimum level of upgrade (m AHD)	8.2 at bridge crossing, or 6.2 about 1000 m south of river
Is the upgrade immune to flooding by 100 year ARI flood event?	Yes
Increase in flood levels upstream of the bridge due to upgrade (afflux)	7 mm
Increase in existing velocity under the bridge and time of inundation for duplicated highway	negligible

Source: Working Paper No. 4

Camden Haven River

Hydraulic modelling of the proposed highway duplication showed that it would be possible to raise the carriageway level above the predicted 100 year ARI level with minimal flooding impacts. The Proposal in the vicinity of the Camden Haven River therefore involves duplicating the existing bridge and positioning the new northbound carriageway so that overtopping would no longer occur during the predicted 100 year ARI peak flood level.

The proposed provision of twin box culverts to replace the existing sunken culvert about 200 m north of the northern bank of the river helps to compensate for the effects of raising the highway to prevent overtopping in the 100 year event. The net effect of the Proposal as predicted by hydraulic modelling is that flood levels on the upstream side would increase by a small amount, about 13 to 15 mm in a 100 year ARI event. On the downstream side, there would be a negligible change in levels in a 100 year ARI event. The predicted change in afflux of 13 to 15 mm is small and no amelioration measures, apart from replacement of the sunken box culvert with larger twin culverts, are considered necessary.

The Proposal would have a negligible impact on the risk of flooding upstream and downstream of the bridge. In addition, it is predicted that there would be no increase in the peak velocities in the river under the bridge for the duplicated highway, and that the Proposal would have a negligible impact on the time of flood inundation of the Camden Haven floodplain.

These results are summarised in Table 9-5.

Table 9-5 Camden Haven River flood summary

	At bridge crossing (upstream)	500 m north of the bridge (upstream side)	1 km south of the bridge (downstream side)
Predicted 100 year flood level (m AHD)	3.97 (with upgrade ⁽¹⁾)	4.20 (with upgrade ⁽¹⁾)	3.8 (with upgrade ⁽¹⁾)
Minimum level of upgrade (m AHD)	6.0	4.8	4.2
Is the upgrade immune to flooding by 100 year ARI flood event?	Yes	Yes	Yes
Increase in flood levels due to upgrade (afflux)	13-15 mm	13-15 mm	negligible
Increase in existing velocity under the bridge for duplicated highway ⁽²⁾	negligible	-	-

Source: Working Paper No. 4

Notes: 1 Upgrade consists of the highway duplication (two lanes) above the 100 year ARI peak flood level, and two culverts

2 Depth and width averaged velocities under the bridge

Herons Creek

Hydraulic modelling was undertaken to assist in the design of waterway structures near Herons Creek so that the predicted extent of flooding upstream of the river crossing is not significantly increased from that existing by the upgrade proposals, whilst still addressing the flood prone nature of the existing highway.

At Herons Creek the Proposal would incorporate the following:

- existing highway would be raised to provide protection from the 1 in 100 year ARI flood level
- duplication of existing Herons Creek 32 m long floodway bridge opening by addition of a new bridge on the west side
- replacement of existing 24.5 m long Herons Creek bridge in poor condition with a new single span 24.5 m long bridge, with a duplicate 24.5 m span bridge on the west side
- upgrading of existing culvert at Station 21280 from a 0.45 m diameter pipe to three number 3.0 m wide x 2.1 m high box culverts in order to reduce the afflux resulting from raising the level of the existing highway.

Simulating the above upgrade proposals in the hydraulic model, it is predicted that the increase in 100 year ARI peak flood level would generally be less than 50 mm and would not affect any existing residences or buildings. The 100 year ARI peak flood level is predicted to increase by the following margins:

- 45 mm between the Pacific Highway and the railway line
- 30 mm upstream of the railway line
- 180 mm a localised undeveloped area immediately to the southwest of the Herons Creek Road intersection with the highway (Station 20950).
- 20 mm immediately downstream of the Pacific Highway bridges.

Refer to Section 2.4 of Working Paper No. 4 for further details.

The Proposal would not be affected by flooding across the Herons Creek floodplain during the predicted 100 year ARI flood event and would not have a significant effect on the predicted flood levels upstream of the bridge crossing.

These results are summarised in Table 9–6.

Table 9–6 Herons Creek flood summary

	Main channel	Flood channel	South of flood channel
Predicted 100 year flood level (m AHD) immediately upstream of highway	7.04 (with upgrade ⁽¹⁾)	~7.04 (with upgrade ⁽¹⁾)	~7.15 (with upgrade ⁽¹⁾)
Minimum level of upgrade (m AHD)	7.3 (Sta 21550)	7.4 (Sta 21460)	7.3 (Sta 21260)
Is the upgrade immune to flooding by 100 year ARI flood event?	Yes	Yes	Yes
Increase in flood levels upstream of the bridge due to upgrade (afflux)	45 mm	45 mm	180 mm
Increase in existing velocity under the bridges for duplicated highway	not significant	not significant	-

Source: Working Paper No. 4

Note 1 Upgrade consists of the highway duplication above the 100 year ARI peak flood level, and three RCBC cells at Station 21280.

9.3 Proposed mitigation measures

9.3.1 General mitigation measures

Water quality management during construction and operation of the Proposal would be in accordance with the following guidance:

- *RTA Specification G38 Soil and Water Management (Soil and Water Management Plan)* (RTA 2004c) and *RTA Specification G39 Soil and Water Management (Erosion and Sediment Control Plan)* (RTA 2004b)
- *RTA Water Policy* (RTA 2001b), *RTA Code of Practice for Water Management* (RTA 1999e) and *RTA Best Practice Notes* (RTA 2002)
- *Managing Urban Stormwater: Soils and Construction 'Blue Book'* (Landcom 2004).

Prior to commencement of construction, the construction contractor(s) would develop the following:

- A Construction Environmental Management Plan that would detail the environmental protection practices, resources and sequence of activities required for compliance with the requirements of the RTA's Specification for Environmental Protection.
- A Soil and Water Management Plan, as outlined in the Blue Book and RTA Specification G38, addressing soil erosion and sediment pollution during construction, including measures to mitigate the potential for impacts on the water environment.
- A Works Method Statement, providing detailed information on work method all for waterway structures and works near watercourses.
- A series of Erosion and Sediment Control Plans (ESCP) for different stages and sections of construction (e.g. for each river crossing). Each plan would be developed to achieve best practice stormwater management.

Specific measures to mitigate the potential impacts on the water environment during construction and operation of the Proposal are described below.

9.3.2 Measures for impact mitigation during construction

The construction of the Proposal has the potential to introduce contaminants to waterways as described in Section 9.2. Some appropriate measures that would be adopted to assist in the mitigation of potential impacts during construction are described below.

Fuels, oils and chemicals

Generally, cabins, containers, workshops, plant, materials stores and storage tanks would not be sited on the floodplain of watercourses. Where this would be unavoidable, for bridgeworks for example, appropriate mitigation measures would be resolved in consultation with DIPNR.

Areas for storage of oils and other hazardous liquids used during construction would be bunded and secure, and any spillage would be collected and disposed of off-site at a licensed facility.

No refuelling would be undertaken in, over, or adjacent to watercourses. Plant would be refuelled in a designated bunded area at least 10 m away from watercourses. Drip trays would be placed under standing machinery. All repair and maintenance work to plant and vehicles would be subjected to the same precautions as fuel storage. Only emergency repairs would be permitted on the site and all routine maintenance of vehicles and large equipment would be carried out away from the site.

Contingency plans and equipment would be in place in case of an uncontained fuel spillage during construction works. Emergency procedures including pollution response plans would be drawn up and agreed with the RTA to avoid water pollution in the event of any accident or spillage. Site personnel would be trained as appropriate. Adequate stocks of absorbent materials, such as sand or commercially available spill kits and booms would be available at all times.

Waterways

Disturbance of watercourses by construction works would be avoided wherever possible. Where works are necessary in waterways, special precautions would be required to reduce erosion and sediment impacts. Where construction access across a waterway is essential, the crossing would be stabilised or a temporary bridge or culvert crossing would be constructed.

Where construction of temporary work platforms is necessary within rivers and creeks for bridge construction purposes, the platform would be designed to minimise the disturbance to the riverbed. Suitable measures would include the placement of geofabric below the platform and placement of suitably sized rock around the platform for the prevention of scouring in periods of higher flow.

Depending on the type of works, construction of an impervious bund (e.g. cofferdam) would be considered to prevent water entering the area of works. No water would be allowed to escape from the cofferdam into the watercourse during the works.

Where work in watercourses is required (e.g. culvert installation), these works would be carried out under the shortest possible timeframe and in as dry a condition as possible. Culverts would be installed as soon as practicable to ensure that adequate transverse drainage is in place in the early stages of construction.

Works including permanent stream protection measures would also be completed in the early stages of construction. Where possible, early installation of culvert wing walls is important so that waterway erosion and sediment impacts are minimised.

Waterways would be protected by strategically placed sediment fences that reduce the potential for sediment to enter waterways. The sediment fences would be extended above culvert wingwalls and headwalls following their construction, and would not be removed until the site has been effectively stabilised.

The *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (DPI 1999b) recognises that snags in waterways form one of the most important habitat components for fish within a river or creek and advises that they should be retained to the greatest extent possible. Snags consist of whole trees, limbs and root masses that are partly or wholly submerged. Where the removal of snags is necessary, DPI suggests they should be relocated to areas of the river or creek either upstream or downstream of the proposed construction works. These snags should remain in this position on completion to reduce handling and further habitat dislocation.

If riparian vegetation needs to be removed during site preparation, the 'cut stump' method of removal is preferred. Retaining the tree stumps assists in stabilising batters and maintaining natural scour protection.

The placement of concrete into forms in or close to any watercourse would be carefully controlled. The use of quick setting mixes may be appropriate in some cases.

Barriers would be constructed on crossings or around working areas of watercourses during bridge cleaning and repainting and other works to prevent excessive amounts of dust and spray entering the watercourse.

Piles for the bridges would be driven, to minimise the potential for groundwater drawdown or contamination that would be more likely to occur if piles were bored and cast in-situ. Driven hollow steel tubes or driven concrete piles also reduce the disturbance to PASS and the riverbed during construction compared to bored piles.

General erosion and sediment control measures

Clean runoff from undisturbed areas would be diverted around the construction site by a series of temporary and permanent diversion and catch drains. These drains would be provided above cuttings and embankments to ensure that uncontaminated runoff is kept separate from contaminated runoff from disturbed areas. The drains would be installed as soon as practicable and prior to the commencement of heavy earthworks, to reduce the volume of runoff passing through disturbed areas.

Catch drains, toe drains and diversion drains would be lined where necessary according to the slope and volume of water, and may also require riprap or other suitable protection in steep areas to control erosions and reduce velocities.

Wherever possible during the clearing stage, grassed drainage lines and grass/shrub cover on the soil surface would be retained to minimise topsoil runoff when heavy construction commences. The topsoil would be kept in place in areas not being excavated to prevent exposure of the subsoil during clearing operations.

Erosion and sediment controls would be implemented across the site to reduce erosion and contain sediment. Sediment controls could include sediment fences, straw bales, vegetation barriers, rock barriers and other containment devices.

Wherever possible, cleared native vegetation and native mulch would be used to reduce erosion, and filter/trap sediment during construction by using small/low vegetation filter windrows placed across the contour in drainage lines or in other appropriate locations. Suitable locations include areas below fill batters, below cutting works, on the contour, at the head of cleared small drainage lines (not impacting fish passage), and before the inlet to sediment basins/waterways to minimise sediment entry into these basins/waterways. Wherever possible, branch heads and smaller timbered material would be used and larger trees only used in the larger vegetation filter windrows where sedimentation may be heavier or where larger water flows may occur from the disturbed site. The vegetation filter windrows would be spread out at the conclusion of construction works.

Temporary windrows would be used to keep runoff from spilling over embankment batters during construction, and used in combination with temporary batter drains to enable controlled discharge of runoff down battered slopes without causing erosion.

Disturbed areas would be revegetated or sealed as soon as practical. Working platforms would be constructed with rock fill to the extent possible so that bare earth that could be subject to erosion is not exposed.

Discharge of sediment and other pollutants from dewatering activities would be controlled. Polluted water may need to be treated on-site before being discharged from the sedimentation basins (see below). Special care would be taken near the river crossings where groundwater could be contaminated by ASS or near Herons Creek where contamination of the existing groundwater has been detected.

All erosion and sediment control measures would be regularly inspected and maintained. In addition, the construction contractor would engage a qualified soil conservation officer on a regular basis to undertake inspections of temporary and permanent erosion and sedimentation control devices to ensure that the most appropriate controls are being implemented and that they are being maintained in an efficient condition.

Sedimentation basins

The Proposal includes an extensive network of sedimentation basins for use during construction. Forty-two such basins would be installed to protect sensitive downstream environmental areas such as SEPP 14 wetlands and National Parks. This equates to approximately two basins per kilometre of highway. The principal function of these basins would be to intercept as much sediment-laden runoff as possible from the construction areas and to retain sediments from exposed areas during construction prior to discharging into natural drainage lines. They would be installed prior to the commencement of construction and would remain in place for the duration of construction and the completion of stabilisation and rehabilitation works.

As previously noted, the overland filtration strategy has been adopted where possible to avoid concentrating and treating all runoff. The concentration of flows into sedimentation basins has been limited to those areas where there are sensitive downstream aquatic habitats while also considering the vegetation which would need to be cleared for a basin, land availability for basins, and ground slopes at potential basin sites. In areas where the availability of land is limited adjacent to the highway and the land is flat, consideration has been given to longitudinal basins that can be provided within a comparatively narrow road reservation.

The basins have been sized for retention of the 75th percentile five-day storm event, in accordance with recommendations in the Blue Book for dispersive soils with a high percentage of fines (defined as > 33% passing 0.02 mm sieve size). This design involves a risk-based approach where the optimal amount of stormwater treatment varies according to the soil conditions that are prevalent on site and the sensitivity of receiving waters. The 75th percentile five-day rainfall event corresponds to a level of risk of a decline in water quality of the receiving waters which is considered appropriate for the protection of SEPP14 wetlands and waterways if used in combination with other soil and stormwater management practices. It is also consistent with the design approach adopted on other recent RTA highway upgrade projects. Further information on the design and location of sediment basins is included in Working Paper No. 2.

Figures 6-1A to 6-1N show the location of both the temporary sedimentation basins and permanent water quality control ponds proposed for the construction of the highway upgrade. The sediment basins have been set as close as possible to the waterway, maximising the capture of site run-off and minimising the area of cleared land.

Surface water runoff from the disturbed areas would be directed to the sedimentation basins via a series of catch drains and diversion drains designed to control the volume and velocity of flows during construction.

There is the potential for dispersive soils to be present at the site and the soils have a high percentage of fines. It is therefore likely that dosing of captured stormwater runoff with a chemical agent (i.e. flocculant) to facilitate settling and help manage the turbidity of discharged stormwater would be necessary to achieve an acceptable quality for subsequent release.

Stormwater in the settling zone would be drained or pumped out within five days (the time period adopted in the design of the basin) of the commencement of rainfall if the nominated water quality targets can be met. Flocculation would be employed where extended settling fails to meet this objective within the nominated (5 day) time period. According to the Blue Book, treated discharge waters should not contain more than 50 mg/l of suspended solids in the design rainfall event. More stringent requirements may be necessary in particularly sensitive environments (i.e. upstream of SEPP 14 wetlands), or, where applicable, can be required by Council stormwater management plans.

Following settling processes and treatment as necessary, runoff could be reused for dust suppression along designated haul routes and to dampen stockpiles or other exposed areas provided that the storage capacity of each basins for future rainfall events is not compromised by using the basins as storage facilities.

The sedimentation basins would be cleaned out on a regular basis as necessary to ensure the build up of silt is removed. Sediment removed from the basins would be treated if necessary and disposed in places that would not result in future erosion or pollution hazard.

Drainage control

Regular inspections of the highway would be carried out at locations of new or upgraded transverse drainage structures (RCBC structures) during construction activities to ensure appropriate measures are provided to mitigate any potential flood inundation impacts.

9.3.3 Measures for impact mitigation during operation

A total of 23 permanent water quality control ponds would be provided as part of the permanent highway drainage system for the Proposal. Of these 23 ponds, 16 are to be located on the western side of the highway and 7 on the eastern side of the highway. These water quality control ponds function as both water quality control ponds to contain and treat runoff from the highway, and as chemical spill containment basins. They have been selected for retention from the 42 sedimentation basins that would operate during construction (see Figures 6-1A to 6-1N) based on the quality and degree of sensitivity of the downstream environment. Further information on the design and location of water quality control ponds is included in Working Paper No. 2.

During normal flow conditions, contaminants in the highway runoff would be contained within the permanent water quality control ponds where they are provided. The ponds have also been designed to retain chemicals such as hydrocarbons that are non-soluble and less dense than water through the installation of an Ellis pipe. An Ellis pipe is an inverted pipe that prevents hydrocarbons and other substances lighter than water from flowing out of the pond. The pipe causes a permanent pond of water to collect in the wet-basin or chemical trap above the outlet point. This permanent pond of water provides a surface above which oils or hydrocarbons can float, while stormwater flows out of the pipe. Vegetation would re-establish in and around the permanent water quality control ponds, which would assist with the settlement of sediment and nutrient removal from the runoff. In addition, the ponds would have the capacity to contain emergency spillage up to a volume of 20 m³ (the volume of a typical tanker). Figure 9-5 presents an indicative layout of the water quality control ponds to be installed along the Proposal route.

Overflow structures from water quality control ponds would be designed to accommodate a 1 in 100 year ARI flood event to safeguard against structural failure.

The water quality control ponds would be cleaned out on a regular basis as necessary to ensure any sediment build up is removed.

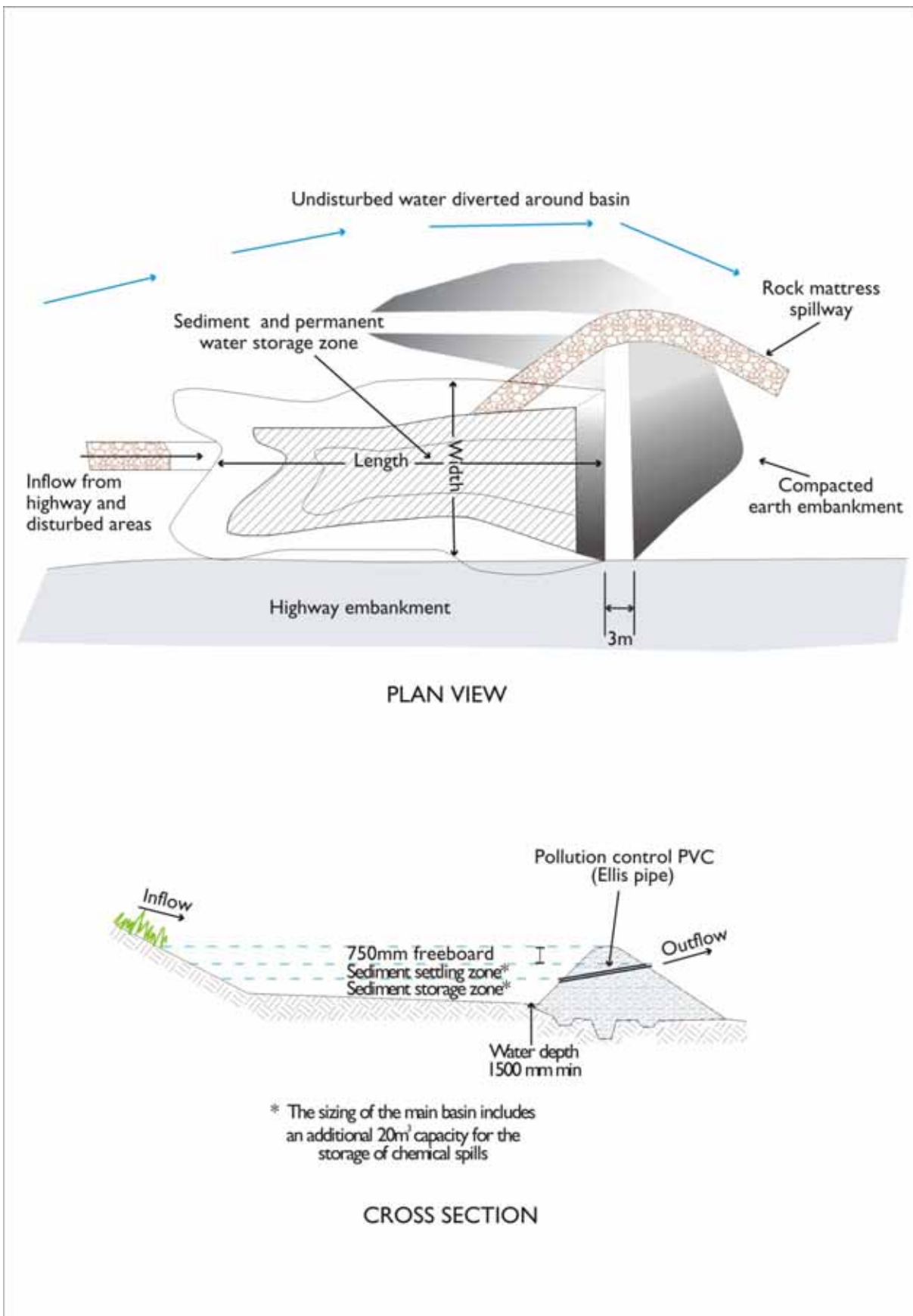


Figure 9-5 Indicative layout of water quality control ponds

Scour protection would be provided at the inlet/outlets of culverts where appropriate to minimise scour erosion. RTA and the Blue Book recommendations would be adopted in the detailed design phase to ensure that scour protection is adequate. Scour protection also needs to be designed in an environmentally sensitive manner, taking into account aquatic ecology and fish movement as well as stream issues. Bank and bed protection would be considered.

The highway drainage, including grassed open drainage channels along the toe of the highway batters and culverts, would be inspected on a regular basis and appropriate measures would be taken (e.g. scour protection, rip rap, revegetation) to ensure any observed erosion is controlled.

9.4 Monitoring

9.4.1 Surface water

A surface water quality monitoring program would be developed and carried out to monitor water quality upstream and downstream of the construction areas in the vicinity of the major waterways during and for a short period following construction to determine the efficiency of the proposed mitigation measures. Monitoring would be carried out to measure the following parameters and indicators:

- pH
- electrical conductivity
- turbidity
- dissolved oxygen
- acidic runoff from either ASS or acidic soils with high aluminium toxicity
- suspended solids and/or turbidity associated with the discharge from sedimentation basins.

It is likely that it will be necessary to apply chemical agents (flocculants) to facilitate settling processes and control the turbidity of discharged runoff from sediment basins.

9.4.2 Groundwater

Piezometers would be required at various boreholes to monitor water levels and water quality. These piezometers would be monitored at regular intervals during the detailed geotechnical investigation which would take place as part of the detailed design phase.

9.4.3 Site of former Herons Creek service station

As noted in Section 8.6.1, it is proposed that further testing would be carried out at this site during the detailed geotechnical investigation (detailed design phase) of the Proposal. The most appropriate treatment and/or the need for further monitoring during construction would depend on any remaining level of contamination encountered at that time, and would be agreed in consultation with RTA and the EPA.

9.5 Implications for ESD

9.5.1 Precautionary principle

Water quality sampling was carried out to develop a baseline on the existing conditions within major waterways crossed by the Proposal. Samples were compared with the water quality parameters under the ANZECC 2000 guideline levels and any exceedences were identified. The design of mitigation measures to control the volume and extent of surface water runoff was carried out to ensure compliance with the relevant guideline levels. In particular, the design of sedimentation basins has been based on the 75th percentile five-day storm event. The precautionary principle has been adopted with regard to the concept design of the basins due to the high importance of local commercial and recreational fisheries and the sensitive ecology of downstream SEPP 14 wetlands to the north of the Camden Haven River crossing. Regular monitoring would be carried out during construction to detect variations or anomalies in local water quality and to implement appropriate measures to avoid any potential long-term irreversible damage occurring.

9.5.2 Intergenerational equity

The importance of complying with relevant guidelines (ANZECC 2000) is recognised as essential in terms of ensuring that the future water quality of Stewarts River, Camden Haven River and Herons Creek and associated tributaries would not be compromised by the construction and operation of the Proposal. The range of future beneficial uses of these waterways would thus be protected for future generations.

9.5.3 Conservation of biological diversity

High water quality is an essential element in the maintenance and enhancement of biological diversity, especially within or in proximity to areas of particular ecological significance such as SEPP 14 wetlands and National Parks. Measures to protect these areas from contaminated runoff are consistent with the conservation of biological diversity, particularly in relation to fisheries resources in the local river (Stewarts and Camden Haven) and lake (Queens and Watson Taylors) systems.

9.5.4 Improved valuation and pricing of environmental resources

Recognition of the ecological and economic importance of good water quality is essential to the community well being especially where there are economic, recreational and other activities such as oyster growing, commercial and recreational fishing reliant on particular water quality levels.