

## 7.0 SYSTEM YIELDS WATERPARK & SANDY CREEKS

Yield estimations have been undertaken with respect to the Waterpark Creek and Sandy Creek sources. A summary of the relevant results is provided in Table 7.1 (see Section 7.3). Full details of the modelling undertaken to derive the system yields are presented in Appendix A.

### 7.1 Maximum Diversions

In assessing yields consideration has been given to the following maximum rates of diversion.

- € Waterpark Creek (1) 17ML/d and (2) 34ML/d.
- € Sandy Creek (1) 18ML/d and (2) 36ML/d.

The existing Waterpark Creek water supply system has a capacity to divert 17ML/d and current planning envisages a capacity to divert 18ML/d from Sandy Creek. In addition to these diversions, consideration has been given to increasing the maximum daily diversion rates from each source. To gain an insight into the yield able to be obtained from increasing the rate of diversions consideration has been given to the yield obtained from both creeks if the maximum daily diversion from each creek was doubled. In some cases, where the maximum diversion rate is double, the total volume of water diverted exceeds the existing allocation held by Livingstone Shire Council. Doubling of the diversion was done merely to gain a full appreciation of the relationship between diversion rate and yield. It is not intended that the existing allocation be increased.

## 7.2 Environmental Flows

### 7.2.1 Definition

An environmental flow is defined as the portion of a waterway's flow that needs to be released downstream from an impoundment in order to maintain aquatic ecosystems, river health and water quality<sup>1</sup>. Environmental flows are often expressed in terms of a flow duration curve (e.g. an 80th percentile environmental flow protects flows that are normally exceeded 80% of the time).

The timing, volume and quality of environmental flows are all critical aspects and, like the natural flow of waterways, different combinations will provide a different range of benefits for each ecosystem. Environmental flows contribute to the functioning of key chemical, geomorphologic and ecological processes necessary for healthy river ecosystems.

### 7.2.2 Issues Associated with not Achieving Adequate Environmental Flows

Critical physical and chemical processes may be affected if the natural magnitude and variation of freshwater inflow to coastal waterways is modified. Some of the processes potentially at risk due to flow modification have been briefly summarised on the following page<sup>2</sup>.

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<sup>1</sup> Lower Clarence County Council and ERM (1999) *Regional Water Supply Project - Environmental Impact Statement - Volume 4 Riverine Impact Assessment*.

<sup>2</sup> Unless cited otherwise, all information provided in this section has been sourced from:  
<http://www.ozestuaries.org/indicators/indicators.html>

- € Nutrient supply and primary productivity. Reduced freshwater inflow can promote algal blooms because the residence times of algal biomass and nutrients are increased, and because fine sediment loads are reduced (hence turbidity decreases and light penetration increases).
- € The salinity regime. Most estuarine biota has specific salinity requirements that may vary depending on the stage that they are at in their life cycle. Many fish species use freshwater and saltwater habitats at various times (i.e. opportunistically, annually, seasonally) and for different reasons (i.e. early development, growth, spawning) during their life cycles (e.g. mullet, bass and barramundi), and the salinity gradients have been identified as the most important factor in the successful recruitment of larval and juvenile fish in a number of estuaries. The dissipation of salinity gradients under reduced freshwater inflow or enhanced tidal flows has the potential to contract the amount of freshwater habitat available to some species. In addition, weirs and physical barrages can impact upon longitudinal and lateral connectivity in the "critical chain" of habitat types required to maintain a productive and diverse fisheries resource.

Geomorphologic changes may also occur in coastal waterways with impacted freshwater flows because sediment supply and movement are altered. A brief summary of these changes follows.

- € A reduction in flood frequencies (e.g. due to the instillation of a major dam in the catchment) has been linked to increased sediment deposition and reduced erosion in downstream coastal waterways. Channel dimensions in coastal waterways are principally determined by the scouring action of floods. A reduction in flood frequency typically results in gradual subtidal shoaling, formation of sandbars, and constriction of channels. Conversely, increased flood frequency (e.g. due to extensive catchment clearing) can result in greater erosion of channel banks and alteration of estuarine geomorphology.
- € Geomorphologic changes at the entrances of wave-dominated coastal waterways may also result due to changes in freshwater flow. Reduced flow, and consequently reduced erosive capacity, can result in greater incursion of marine-derived sediments (e.g. sands) into coastal waterways, causing expansion of flood tidal deltas. Such entrance constriction may lead to an increased frequency of entrance closure in coastal lagoons, and small wave-dominated estuaries, with subsequent issues of extreme changes in estuarine biogeochemistry.
- € Alteration of entrance geomorphology, channel width, and formation of internal sand bars also has consequences for alteration of tidal penetration within coastal waterways.

Aquatic ecological sustainability is strongly linked to flow variability. The reduction of variability within waterways can negatively impact upon ecological sustainability.

### **7.2.3 Description of Current Environmental Values of Sandy Creek**

An inspection of the proposed Sandy Creek weir site and various downstream areas was completed on the 12<sup>th</sup> of October 2004. During this inspection, the following observations were made.

- € The proposed weir site occurs at an Adopted Middle Thread Distance (AMTD) of approximately 3.3km in a permanently freshwater section of Sandy Creek. The site occurs in the reach of the lower catchment of Sandy Creek above tidal influence and is characterised by sandy soils, which overlies sedimentary rock.

There is a notable absence of vegetation growing within the bed of the creek at this site, with the exception of a few isolated clumps of Grey rush (*Lepironia articulata*), which occur at the edge of the creek bed.

- € The vegetation adjacent to the creek consists of predominantly eucalypt and allied species open forest (i.e. *Melaleuca* spp., *Lophostemon suaveolens*) with a mid-dense to dense rainforest species dominated understorey. The vegetation growing on and adjacent to the creek's banks appears to be in good health, which is in contrast to vegetation in the surrounding locality, away from the creek, which appears to have been negatively impacted upon by the effects of the ongoing drought.
- € A site known as Ray's Crossing occurs downstream of the proposed weir site, at an AMTD of approximately 3km. Water levels at Ray's Crossing fluctuate regularly as a consequence of tidal influences. Measurements of salinity at Ray's Crossing (i.e. electrical conductivity measured in micro Siemens per cm ( $\sigma$ S/cm)) were collected by Livingstone Shire Council (LSC) on the 27<sup>th</sup> August 2004 at a tide level in Rosslyn Harbour of 4.53m. The results indicated a change in electrical conductivity from 85 to 392 $\sigma$ S/cm due to the influence of the advancing tide. The vegetation at Ray's Crossing is similar in composition to that of the proposed weir site and appears to be in good health.
- € A site known as Palm Grove occurs approximately 200m downstream of Ray's Crossing at an AMTD of approximately 2.8km. Electrical conductivity was recorded by LSC at this site on the 28<sup>th</sup> of August 2004 at a tide level, in Rosslyn Harbour, of 4.7m. Over the course of a two hour period (i.e. 8pm to 10pm), electrical conductivity increased from 85 $\sigma$ S/cm to 19,130 $\sigma$ S/cm. The latter reading indicates that, during high tides, this section of Sandy Creek is regularly subject to short duration tidal pulses that create highly saline conditions. It is relevant to note that no marine vegetation was observed at this site. The vegetation is characterised by a relatively similar suite of species as at the proposed weir site and Ray's Crossing, with the exception of fewer *Melaleuca* spp. stems and an increased abundance of Alexandra palms (*Archontophoenix alexandrae*). It is relevant to note that, at this site, plant species typically associated with freshwater environments (i.e. Grey rush, Tree-ferns, rainforest understorey species etc.) occur along the banks of the creek. The fact that these species have established and persisted within this section of the creek corridor indicates that they are tolerant of the regular tidal pulses within the creek channel.
- € The original weir site, located at an AMTD of approximately 2.7km, occurs downstream of the Palm Grove site. At this site there are obvious vegetative indicators of tidal influence in the form of scattered Mangrove lily (*Crinum pedunculatum*), and estuarine sediment deposits on the banks of the creek, which are highly visible at low tide. Baseline measurements of electrical conductivity (i.e. 175 $\sigma$ S/cm) indicate slightly more saline conditions than the preceding upstream sites. It is relevant to note that despite the occurrence of the Mangrove lilies, the creek banks predominantly support plant species associated with freshwater environments, such as tree ferns (*Cyathea* spp.). These species currently grow below the creek's high tide mark and, as such, would be partially to fully submerged at high tide.

- € A site referred to by LSC as Joe's Pump Station, occurs downstream from the original weir site. Although electrical conductivity at this site has been recorded as high as 30,000 µS/cm during high tide, freshwater is pumped from the creek at this site during low tide. The vegetation is characterised by marine species such as Mangrove lily, Mangrove fern (*Acrostichum speciosum*), Native hibiscus (*Hibiscus tiliaceus*) and a variety of mangrove seedlings. The site also supports, on its upper banks a mix of freshwater species including Cabbage tree palm (*Livistona* spp.), *Melaleuca* spp., Monkey rope (*Parsonia straminea*) and rainforest understorey species similar in composition to the upstream sites.
- € Sandy Creek supports a permanent estuary downstream of Joe's Pump Station. At this site the vegetation is dominated by marine plant species such as Mangroves, Native hibiscus, Mangrove lily etc. Larger trees (e.g. *Lophostemon suaveolens*, *Livistona* spp.) occur adjacent to the creek's banks in addition to a highly disturbed understorey that is characterised by exotic grasses (e.g. *Panicum maximum*).

#### **7.2.4 Description of Current Environmental Values Downstream of Waterpark Creek Weir**

Currently, there is no established minimum flow at the Waterpark Creek weir. During dry periods, water extraction continues even if no base flow passes over the weir. Under the current proposal, it is intended to establish a minimum passing flow of 50L/s.

A brief inspection of the riverine environment downstream of the existing Waterpark Creek weir was completed on the 12<sup>th</sup> of October 2004. The inspection was completed adjacent to the location of the proposed pipeline crossing, along a tidally influenced section of the creek. The vegetation at the edge of the creek is characterised by marine plant species (e.g. Holly mangrove (*Acanthus ilicifolius*), Mangrove fern, Mangrove lily etc.). An open forest community, consisting of Swamp turpentine (*Lophostemon suaveolens*), scattered Alexandra palms (*Archontophoenix alexandrae*) and a dense to mid-dense rainforest species dominated understorey, adjoins the marine plant margin.

It is relevant to note that although a few dead palms were observed adjacent to Waterpark Creek, the open forest community also supported a high number of living palms in a range of different size classes (6-18m in height). It is also relevant to note that healthy palms were observed closer to the edge of the creek than the few, scattered dead palms. Although it was not possible to accurately determine the cause of the palm deaths, it is possible that these palms, all of which appeared to be quite large in size, died as a consequence of natural causes. Given that palms of both equivalent and smaller size occur closer to the edge, and thus the high tide mark, of Waterpark Creek, it would appear unlikely that these palms have died as a result of altered tidal conditions that may have been caused by the establishment of the upstream weir. Furthermore, it is relevant to note that some of the younger palms are likely to have established since the construction of the Waterpark Creek weir in 1988. Alexandra palms typically display rapid rates of growth and it is reasonable to assume that palms which established since the weir's construction would have attained heights of 6 to 10m.

#### **7.2.5 Department of Environment & Heritage Referral and Decision**

The proposed weir would be constructed on a freshwater section of Sandy Creek, approximately 1,300m north-west of the Sandy Creek-Waterpark Creek junction. At this point Waterpark Creek is tidally influenced and is approximately 2,700m north-west of the furthest landward extent of the Corio Bay Ramsar wetland.

The proposal to construct a weir structure, pump station, pipeline and associated service infrastructure (“the action”) was referred to the Commonwealth Department of Environment and Heritage (“DEH”) on the 28<sup>th</sup> of June 2004 for assessment under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (“EPBC Act”). In the referral, it was stated that:

- € a 1988 Order in Council for water extraction from Sandy Creek permits a maximum diversion of 36ML per day and 7400ML per year, which equates to a pumping rate of approximately 416L/s;
- € LSC has designed the pump station to have a maximum pumping capacity of only up to approximately 200L/s, which equates to 18ML per day approximately;
- € the maximum pumping capacity will only be utilised during flood flow events of greater than 300L/s inflow rate, and would require the simultaneous use of all pumps, which could only be sustained for a maximum of 24 hours;
- € pumping rates at other times would be determined in accordance with operational procedures for Sandy Creek Weir in conjunction with the existing Waterpark Creek Weir; and
- € the intent was to maintain a minimum passing flow of 50L/s (i.e. 4.32ML/day) across proposed weir

DEH issued a decision notice in respect of the referred action on the 26<sup>th</sup> of July 2004, wherein it was stated that the proposed development of the weir structure, pump station, pipeline and associated service infrastructure ‘is not a controlled action’ under section 75 of the *EPBC Act* and therefore would not have, or be likely to have, a significant impact on any matters of national environmental significance (i.e. the Ramsar wetlands of Corio Bay).

### 7.2.6 Summary of Technical Panel Report

LSC established the Waterpark and Sandy Creek Community Reference Group in order for representatives from various stakeholder groups to communicate issues and community concerns associated with the Byfield area to Council. The group raised a number of issues for which answers were not available and, in the absence of data from significant environmental studies, the reference group requested that a panel of experts (i.e. a technical panel) be brought together to advise whether and at what level water can be extracted from Sandy Creek without environmental damage. The panel consisted of:

- € Mike Keane, an executive engineer (hydrologist) from the Department of Natural Resources and Mines;
- € Dr. Marcus Sheaves, from the School of Marine Biology and Aquaculture, James Cook University;
- € Dr. Alistair Melzer, the Director of the Centre for Environmental Management, Central Queensland University; and
- € Ian Halliday, a fisheries biologist from the Department of Primary Industries.

This section summarises the findings of the technical panel.

The technical panel considered the following five scenarios for the extraction of water from Waterpark Creek and Sandy Creek.

1. No change in the current harvest regime – using Waterpark Creek only, leaving 90L/s base flow, shut down of extraction before high tides;

2. Includes removal of base flow from Waterpark Creek – “take what you like if you need it, hammer WaterparkCreek”, whilst leaving Sandy Creek alone;
3. Includes taking water out of Sandy Creek during peak flow events (> 1,000L/s), using Waterpark Creek as per option 1;
4. Includes taking water out of Sandy Creek, leaving a base flow of 200L/s plus using Waterpark Creek as per option 1. After a rain event/increased flow, pumps in Sandy Creek should be left off for three days to allow for ‘a flush’; and
5. Includes taking water out of Sandy Creek, leaving a base flow of 50L/s plus using Waterpark Creek as per option 1.

The technical panel developed “decision matrices” to assess the effect that the 5 scenarios would have upon, physical systems, flora and fauna. Based upon these matrices the panel determined that “Scenarios 2 and 5 caused severe environmental damage while the other 3 Scenarios caused very limited change compared to the current situation”.

The panel further stated:

*The riparian vegetation (e.g. gallery rainforest) is more sensitive to change in base flow condition of these creeks, and is at risk from saline water encroachment with continued low flow conditions coupled with increased water extraction.*

*Based on the precautionary principle, further danger of environmental damage to the Water Park/Sandy Creek system should be avoided by preventing water extraction levels that reduce flows to levels below historical minima for the two systems. If an increase in water harvest is necessary, option 4 would seem the best balance between safeguarding the environment and gaining a reliable water supply in the immediate future.*

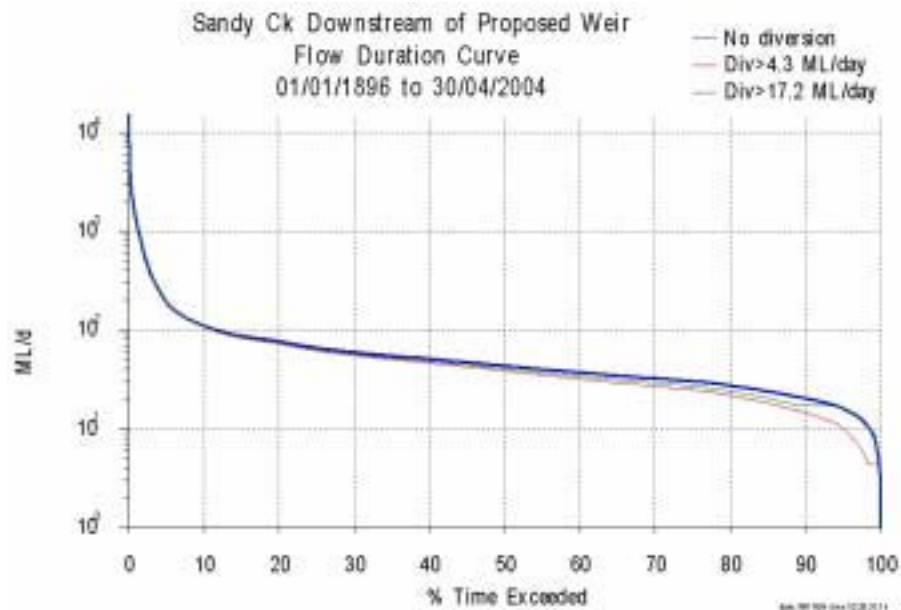
The technical panel did not address water extraction from Sandy Creek at any rates other than those that would leave base flows of 50 and 200L/s.

### **7.2.7 Potential Implications for the Downstream Environment of Sandy Creek**

The frequency and duration of flood events within Sandy Creek are unlikely to have been altered significantly by the construction of the extraction system and weir. Accordingly downstream biota whose lifecycles are dependent upon annual, seasonal or other flooding cycles would not be affected by the construction of the weir and/or the associated water extraction.

The most likely impact that the weir and associated water extraction will have upon downstream environments is during periods of low flow. Under the conditions of DEH decision, water would be extracted from the weir pool at Sandy Creek up until such point as the incoming flow drops to below 50L/s, whereupon pumping would cease in order to maintain the minimum passing flow.

It is relevant to note that flows of 50L/s and below, under natural conditions are rare occurrences. A flow duration curve for Sandy Creek was generated from estimates of flow within the waterway, based on modelled data from January 1896 to April 2004. This flow duration curve is presented as Graph 7.1 (see next page). Based upon this data, it is apparent that flows of less than 50L/s are achieved very rarely (i.e. approximately 1 day per year) under natural conditions.



**Graph 7.1**

Extracting water at a rate that allows a minimum passing flow of 50L/s will increase the frequency of low flow periods when downstream flow is equal to or less than 50L/s to approximately 6 days per year.

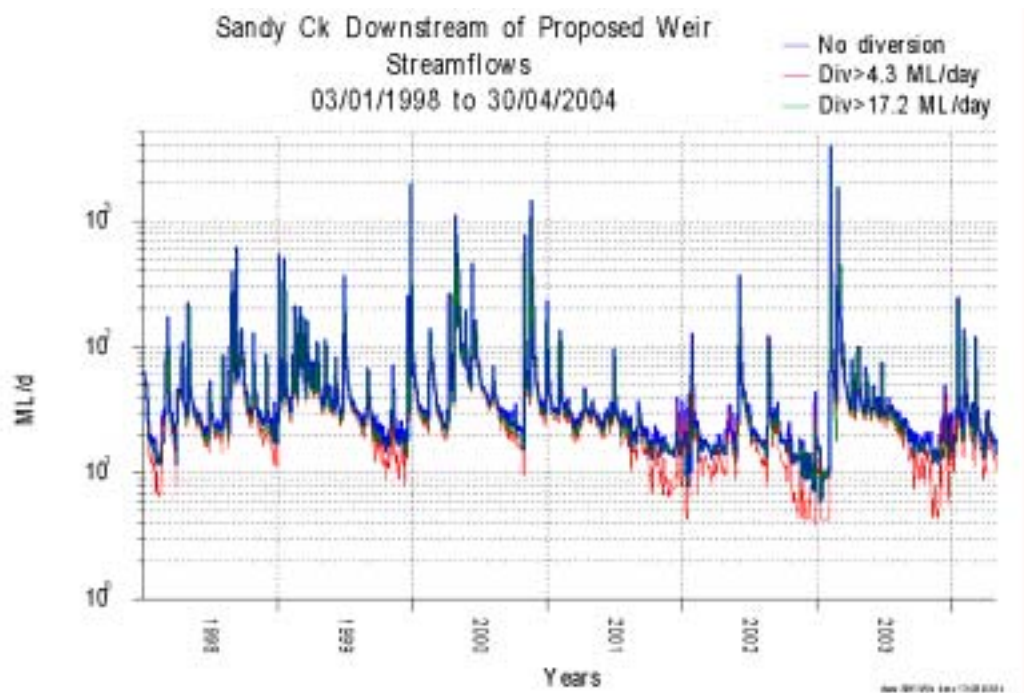
It is relevant to note that although the DEH decision permits a minimum passing flow of 50L/s or 4.32ML/day, it would be feasible to allow an increased minimum flow to pass. Under such a possibility the presence of the weir and the action of water extraction would increase the frequency of low flow periods, by allowing an increased minimum passing flow, the increased frequency and duration of these low flow periods will not be as high those occurring under the 50L/s model.

Although the likely impact of increasing the frequency and duration of low flow periods upon downstream biota is uncertain, it is relevant to note the following.

- ⊘ The design of the weir will incorporate a 'rock-ramp' fishway that will facilitate the movement of fish and other aquatic organisms. As such, the weir will not present a barrier to the natural upstream or downstream dispersal of aquatic organisms.
- ⊘ The environment downstream of the proposed weir site extends for a distance of approximately 1,300m before joining WaterparkCreek. At present, permanent freshwater conditions extend for a distance of approximately 300m downstream of the proposed weir site to Ray's Crossing which, at high tide, is the furthestmost point of tidal reach. The relatively small size of the permanently freshwater downstream environment is likely to limit the diversity of habitat types available to aquatic biota and hence, the extent of habitats that are sensitive to slight modifications in flow. It should be noted that a similar suite of plant species occur on the banks of Sandy Creek at the proposed weir site, Ray's Crossing and the more tidally influenced Palm Grove and original weir sites. This indicates that the plant species that occur in the potentially affected section of Sandy Creek are tolerant of the short duration saline pulses that occur during high tides and would be unlikely to be displaced from the downstream freshwater environment as a consequence of slight flow modifications.
- ⊘ Aquatic biota within Australian waterways have generally evolved to be tolerant of the variable nature of flow in these systems and, as such, tend to display considerable robustness and an ability to adapt to altered flow regimes<sup>3</sup>.

<sup>3</sup> Lower Clarence County Council and ERM (1999) *Regional Water Supply Project - Environmental Impact Statement - Volume 4 Riverine Impact Assessment*.

- € Sandy Creek is not an ephemeral waterway in that it is not subject to seasonal periods of no flow. It would be possible to maintain an increased passing flow than the 50L/s approved by DEH. If the minimum passing flow is increased then during periods of flow less than this limit, water would not be extracted from the weir pool. Accordingly, the construction of the weir is unlikely to contribute to increased periods of no flow when the downstream river bed is dry and aquatic biota are forced to retract to 'refugia' (i.e. isolated pools). Furthermore, the construction of the weir and the associated water extraction is unlikely to lead to a fragmentation of aquatic habitats, where aquatic biota are prevented from moving from one pool to another.
- € The potential for a significant increase in tidal reach along Sandy Creek, as a direct result of the weir and its associated water extraction, would be reduced through the maintenance of the minimum passing flow of 100L/s and the topography of the surrounding locality (i.e. land occurring above the level of Highest Astronomical Tide). It is likely that during periods of low flow, saline waters associated with high tides may extend further along Sandy Creek into the 300m long permanent freshwater section of the creek that occurs between the proposed weir site and Ray's Crossing.
- € Flow variability to the sections of Sandy Creek downstream of the proposed weir site would not be significantly altered as a consequence of the weir construction and associated water extraction. Figure 2 on the following page, illustrates the projected changes in flow variability if minimum passing flows of 50L/s (i.e. 4.32ML/day) and 200L/s (i.e. 17.2ML/day) were adopted. It is evident that the controlled models mirror the variations in flow that would be experienced under natural conditions and that it is difficult to discern between the models and natural conditions during periods of high flow (i.e. flood events). It is relevant to note, however, that these models do produce slightly decreased flow amplitudes due to the influence of water extraction. This is particularly apparent during drier years (i.e. 2002-2003) where, under the 50L/s model, periods at or below the minimum passing flow are achieved.



**Graph 7.2**

### 7.2.8 Monitoring

It is also relevant to note that LSC have commissioned the Central Queensland University's Centre for Environmental Management (CEM) to undertake twice yearly vegetation monitoring of Sandy Creek to assess the impacts of the proposed water harvesting. Attributes to be sampled during the course of this monitoring program include species richness, vegetation structure, ground cover, foliage indices and soil indices. Monitoring will occur, once at the end of the dry season (September/October) and once after the rainy season (March/April).

Council have also invited CEM to undertake monitoring of the Sandy Creek macro-benthic community structure, with the aim of specifically addressing any changes to the invertebrate community structure in Sandy Creek that may result from the construction of the weir. This monitoring program will enable a determination of the relative impact of the weir and associated water extraction on downstream environments.

During and following construction of the weir, Council will implement and maintain a water quantity monitoring program that will measure and record:

- € weir pool level;
- € overflow level;
- € diversion quantity (pumped quantity);
- € upstream groundwater level; and
- € downstream groundwater level.

Meteorological data will also be sourced from the Bureau of Meteorology, including temperature, rainfall and evaporation. Council will implement and maintain a water quality monitoring program at upstream, in-storage and downstream sites to measure and record:

- € clarity;
- € pH;
- € conductivity;
- € turbidity;
- € colour;
- € suspended solids;
- € temperature;
- € dissolved oxygen;
- € nutrients;
- € fish surveys; and
- € aquatic algae.

## 7.2.9 Conclusions

Under the current proposal, a minimum passing flow of 100L/s would be established at the Sandy Creek weir and no water would be extracted from the weir when baseline flows reached or fell below this rate of flow. Under this scenario, it is likely that the construction of the weir would result in some alteration to the reach of tidal influence along Sandy Creek and it is expected that this alteration would be most apparent during periods of low flow. However, given that the furthestmost tidal influxes in Sandy Creek tend to be of a relatively short duration and that the vegetation along the predominantly fresh sections of Sandy Creek appear to be tolerant of these regular, highly saline pulses, it is not considered that any increase in tidal reach caused by the construction of the proposed weir would have a significant impact upon the creek's existing biodiversity or general ecological function.

As previously noted, plant species associated freshwater environments (e.g. Tree-ferns, Alexandra palms) are currently growing below the high tide mark at both the Palm Grove and Original Weir sites. During high tide, these plants are partially to fully submerged in highly saline (i.e. >19,000 $\sigma$ S/cm) waters. It is evident through the persistence and ongoing recruitment of these species that they are tolerant of the short saline pulses associated with the high tides.

Following the construction of the weir, it is considered that, during dry periods when baseline flows are low and tidal waters move further inland, there may be some deposition of estuarine sediments and possibly some recruitment of marine species (i.e. Mangrove lily) along sections of Sandy Creek that were not previously exposed to such conditions.

Under such conditions there is likely to be a slight expansion in the extent of Sandy Creek that supports marine plant species and the residence time of saline conditions. However, it should be noted that during wet periods, downstream flows would provide a 'flushing out' of the creek, washing away the estuarine sediment deposits, reducing, and in some cases, possibly preventing the residence time of saline conditions and promoting the establishment of predominantly freshwater conditions. During such periods, it is expected that there would be a slight reduction in the extent of Sandy Creek that supports marine species, as tidal influence would not extend as far along the creek as it would during dry times.

Although it is expected that there will be some alteration to the extent of downstream flows and the upstream tidal reach following the construction of the weir, it is unlikely that such an alteration will be a significant one. The DEH have determined that the construction of the weir and a minimum passing flow of 50L/s will not have a significant impact upon any downstream matters of national environmental significance (i.e. Ramsar wetlands of Corio Bay). No populations of wildlife species protected by the relevant provisions of the *Nature Conservation Act 1992* ("NC Act") would be significantly impacted upon to the detriment of the species' range or continued existence within the surrounding locality, as a consequence of the altered flow regime.

Given the present demonstrated tolerance to the tidal influxes elicited by vegetation growing along the banks of Sandy Creek, it is unlikely that the alterations to flow/tidal influence caused by the weir construction and water extraction would result in a permanent shift in flora species dominance to the point whereby existing remnant vegetation, protected under the relevant provisions of the *Vegetation Management Act 1999*, along the creek would be significantly impacted upon. As such, any alteration to flow/tidal influence within Sandy Creek is unlikely to result in a significant impact to any ecological values protected under the provisions of relevant Commonwealth and State regulations with a biodiversity focus.

Despite the importance of ensuring the continued maintenance of downstream ecosystems, the operating rules for the proposed Sandy Creek weir also need to permit the desired function of the weir. The Sandy Creek weir is to be constructed for the purposes of supplementing current water supply from the existing Waterpark Creek weir in response to a projected increase in population demand on the Capricorn Coast. The Community Reference Group's technical panel proposed that taking water out of Sandy Creek and leaving a base flow of 200L/s in addition to maintaining the current use of Waterpark Creek (i.e. leaving a base flow of 90L/s represented the best balance between safeguarding the environment and gaining a reliable water supply in the immediate future.

This option does not, however, consider the impact that dry periods will have upon water supply. During drier times, such as are being experienced at present, implementing a minimum base flow of 200L/s at the Sandy Creek weir would effectively nullify the purpose for which it is intended and would place a higher demand on the water being extracted from the existing Waterpark Creek weir. For this reason, it is proposed that a minimum passing flow of 100L/s be established at the Sandy Creek weir.

It is considered that a base flow of 100L/s would permit ongoing water extraction during drier periods to meet the projected increase in demand, whilst maintaining flows that will enable the continued functioning of downstream ecosystems.

Currently, there is no evidence to support the claim that tidal influences on Waterpark Creek are causing any vegetative dieback.

It is considered that the loss of a few scattered Alexandra palms is more than likely to be a result of natural attrition rather than a consequence of encroaching tides. It is proposed to implement a minimum passing flow of 50L/s at the Waterpark Creek weir where, at present, no baseline flow restrictions are in place. The establishment of this passing flow would minimise the extent of tidal reach along Waterpark Creek during drier periods and would permit continuous downstream movement of aquatic biota.

Although the current state of Waterpark Creek has been modified by the construction of the weir, it is considered that the resultant encroachment of tidal influence along Waterpark Creek does not represent a significant impact to the system and that it is unlikely any wildlife species, protected under the provisions of the *EPBC Act* or the *NC Act*, have been excluded from Waterpark Creek as a consequence of the weir's construction. Although the potential increase in tidal reach during periods of low flow may produce conditions that some freshwater plant species are not tolerant of and, as a consequence, conditions that are more favourable for marine plant species, it is unlikely that any such modification to the flow regime would result in a significant loss or shift in species dominance.

As previously noted, the freshwater plant species that currently occur downstream of the proposed weir site are tolerant of the short duration saline pulses associated with high tides. These species are likely to persist within their current range under the proposed alterations to downstream flow, with the exception of some of the less tolerant species that may be replaced by marine species during extended dry periods when tidal influxes increase along Sandy Creek. It is considered that any such shift in species dominance would be minor and would be unlikely to represent a significant modification to the creek's ecological values. It is also considered that any such shift is likely to be offset during wetter periods when downstream flow is increased, the extent of tidal influence along Sandy Creek is reduced and conditions that are more favourable for freshwater species and less favourable for marine species are created.

### 7.3 Safe Yields

The following yields of the Waterpark Creek and Waterpark and Sandy Creeks system given in Table 7.1 have been determined based on the historic rainfall records and flow measurements. The rainfall record includes the drought year of 1902. For details refer to Appendix A.

**Table 7.1**  
**Safe Yields – Waterpark Creek & Waterpark and Sandy Creeks**

Case	Kellys Offstream Storage Stage	Diversion Waterpark Ck (ML/d)	Diversion Sandy Ck (ML/d)	Environmental Flow (ML/d)		SafeYield (ML/a)
				Waterpark Creek	Sandy Creek	
(a)	1	17	-	4.3	-	2,400
(b)	1	17	-	8.6	-	1,850
(c)	1	17	-	17.2	-	1,450
(d)	2	17	-	4.3	-	4,100*
(e)	2	17	-	17.6	-	2,590
(f)	3	17	-	4.3	-	4,300
(g)	3	34	-	4.3	-	7,770
(h)	2	17	18	4.3	8.6	4,790
(i)	3	34	36	4.3	8.6	9,790

\* yield limited by 4,400ML/a Allocation

### 7.4 Yields based on the Exclusion of Year 1902 Drought

Table 7.2 details the yield which would result from analyses which do not include the period of the year 1902 low rainfall record.

**Table 7.2**  
**Yields – Waterpark Creek & Waterpark and Sandy Creeks**

Case	Kellys Offstream Storage Stage	Diversion Waterpark Ck (ML/d)	Diversion Sandy Ck (ML/d)	Environmental Flow (ML/d)		Yield (ML/a)
				Waterpark Creek	Sandy Creek	
(a)	1	17	-	4.3	-	4,020
(h)	2	17	18	4.3	8.6	7,090
(i)	3	34	36	4.3	8.6	12,700

A comparison of Cases (a), (h) and (i) in Table 7.2 with similar Cases in Table 7.1 shows that the yield increases by 67, 48 and 30 percent respectively. However, care must be taken in adopting the yields given in Table 7.2 as the consequences of failure of supply will be significant and there is no reason to believe the event of the year 1902, or one similar, will not reoccur.

### 7.5 Yield with Restrictions

The implementation of restrictions over a prolonged period would increase the yield of the existing Waterpark Creek supply. Overall yield increases would be approximately 30 percent compared with the yields resulting based on the provision of normal supplies.

Details of the yield available with restrictions applying are given in Table 7.3. The restrictions assume a reduction in demand of 25% when the volume in Kellys Offstream Storage falls to 75% and 50% of capacity.

**Table 7.3  
Safe Yields – Waterpark Creek & Waterpark and Sandy Creeks**

Case	Kellys Offstream Storage Stage	Capacity of Kelly Offstream Storage when Restrictions Applied	Diversion Waterpark Ck (ML/d)	Diversion Sandy Ck (ML/d)	Environmental Flow (ML/d)		Yield (ML/a)
					Waterpark Creek	Sandy Creek	
(a)	1	75%	17	-	4.3	-	2,950
(d)	2	50%	17	-	4.3	-	4,310*
(h)	2	50%	17	18	4.3	8.6	5,550
(h)	2	75%	17	18	4.3	8.6	5,870
(i)	3	50%	17	18	4.3	8.6	9,955*
(i)	3	75%	17	18	4.3	8.6	10,300

\* yield limited by 4,400ML/a Allocation

As can be seen from a comparison of Table 7.1 with Table 7.3, the yields, that can be obtained if restrictions are applied over a prolonged period, are some 15% to 25% greater than the no failure safe yields. Accordingly, it would be reasonable to consider some delay in the construction of major works to augment either the Waterpark Creek system or a combined Waterpark Creek and Sandy Creek system provided restrictions are strictly applied. In this regard, it should be noted that current water consumption is already influenced by the adoption of demand management techniques. Water consumption on the Capricorn Coast is low by Central Queensland standards and it would be unlikely that consumption can be reduced appreciably below current usage.

If reliance is placed on implementing restrictions when the capacity of Kelly Offstream Storage falls to 75% it will be necessary to develop a Drought Management Plan and ensure restrictions do not need to be applied frequently.