8 Catchment scenarios application and biotic links

8.1 Introduction

From the initial planning stages of this project it was desired to link certain abiotic processes to biotic processes on the floodplain so that ultimately rainfall and catchment development scenarios could be input into the model and their effects on a particular species of plant or animal predicted (James, pers. comm.), providing useful information to managers and other researchers. The ability of the hydraulic model developed in this study to determine flows and stages (at any cross-section using HEC-RAS), inundation areas and mapping of these inundation areas including depth contours if desired (using RiverCAD) within the study region made this possible.

The catchment development scenarios (described in Chapter 7) were run through all three of the hydraulic models for each reach (using HEC-RAS). Rainfall additions (in m^3/s) to inundated areas were taken into account using the area-inflow relationships (equations 6.1 to 6.3) and Nylsvley Weather Station historic rainfall records (position shown in Figure 1.3). The same tributary inflow time series were used for all the scenario runs (extrapolated catchment gauge data or in the case of ungauged catchments, modelled data), therefore the scenarios were only in terms of developments in the Nyl River catchments upstream of the N1 crossing (DWAF gauge A6H039).

8.2 Determination of appropriate model resolutions and development of biotic links with wild rice

Biotic – abiotic links were developed with the wild rice (*Oryza longistaminata*) that grows in frequently inundated areas on the Nylsvlei floodplain, as was planned from the inception of this project by the CWE. Wild rice is an important habitat during floods for fish, which are an important source of food for many of the water birds that migrate to the inundated Nylsvlei floodplain. The wild rice is also an important food source for the wild animals of the Nylsvley Reserve and the domestic livestock of farms on the floodplain.

The determination of the desired spatial and temporal resolution of the model was developed with biotic links in mind, in particular with the wild rice. Vegetation on the Nylsvlei floodplain is differentially distributed along three environmental gradients according to Pitman *et al* (1997): distance from the channel, elevation above the channel and distance downstream. Flooding frequency, duration and depth all decrease along these gradients, especially the last two and plant species distribution is a result of species tolerance of flooding and drought fluctuations over time. There have been three major findings from previous vegetation studies (Pitman *et al*, 1997):

- A statistically significant change in plant species composition can be detected for a 9cm change along the elevation gradient. This can be interpreted as meaning that a 9cm change in water depth during flooding and associated water deficit during dry periods, can alter conditions along this gradient sufficiently to affect the persistence of some species.
- At a broader scale three vegetation communities (groupings of plant species with similar environmental requirements) on the floodplain can be recognised along the elevation gradient; the submerged and floating leaved aquatic species in the channel, the wild rice (*Oryza longistaminata*) community at mid-elevations and the Rooigrass (*Themeda triandra*) zone at the highest elevations. There is an elevation differential of 0.5m – 1.0m between these communities.
- The species with the most diagnostic potential in terms of response to flooding is the wild rice, which has been extensively studied by Marneweck (2003). His studies have shown that the wild rice grows best in water depths of between 10 and 50cm. Depths of 50 – 75 cm result in reduced vigour and underground rhizome development with consequences for persistence during droughts. Above 75cm flowering is markedly reduced and the plants become too spindly to remain upright when water levels drop. At least 25 days of flooding is needed for rice to flower and

> set seed if flooding occurs in January or February but longer if flooding is earlier or later in the season. The growth pattern of rice during this 25 day period shows shorter response periods as floods rise and fall suggesting that five-day intervals in water level and distribution would be appropriate for ecological response modelling.

Modelling was carried out at a daily time-step and so exceeded the requirement for temporal resolution. The vertical resolution was recommended to be 20-25cm (as it was thought to be difficult to model the floodplain at a resolution as fine as 9cm) giving at least two model steps between no response and poor response of wild rice to flooding (Pitman *et al*, 1997). The hydraulic model had a vertical resolution of 20cm, determined by the LiDAR survey data. The longitudinal resolution was recommended to be fairly coarse with the floodplain divided into 5 reaches, the three reaches modelled and an upstream reach from Nylstroom to the N1 and a reach downstream of Mosdene. The longitudinal resolution far exceeded this, being governed by the spacing between cross-sections (approximately 20m to 1km), but only the middle three reaches were modelled.

The wild rice also has certain inundation frequency requirements. According to Marneweck (2003), the wild rice goes through its entire ontogenetic life history cycle (consisting of four main distinguishable periods) whether the floodplain is inundated or not, the magnitude of which depends on the occurrence and timing of a flood. These periods are September to November, December to March, April, and May to August (Figure 8.1). Within these periods, five different expressions of the life history response are evident as described by Marneweck (2003): "Firstly… there is a dry period ontogenetic life history response that occurs independent of flooding, the aboveground expression of which occurs between September and March, with culm tiller senescence and ramet dormancy occurring between April and August. The ontogenetic life history response controls all other expressions of the life history response, irrespective of the timing of inundation… depicted by the larger shaded circle in Figure 8.1… Secondly, there is the response when ramets are first inundated during August and September. This includes the stages of emergence and senescence with the growth and reproduction stage changed to a growth and vegetative reproduction stage to indicate that ramets inundated first during these months do not flower and thus do not undergo sexual reproduction. Thirdly, there is the response when ramets are first inundated during October and November. This includes all the stages of emergence, growth and reproduction that occur in response to inundation, and ramets reproduce vegetatively and sexually. Fourthly, there is the response when ramets are first inundated during December, January, February and March. This only includes the stages of growth and reproduction, and senescence, since culm tillers are already established at the onset of inundation because of the dry period ontogenetic response. Lastly, there is the response when ramets are first inundated during April. Again, this includes the stages of emergence and senescence with the growth and reproduction stage changed to a growth and vegetative reproduction stage to indicate that ramets inundated first during April do not flower and thus do not undergo sexual reproduction.”

This life cycle response ensures that the wild rice is able to take full advantage of inundation irrespective of when the flood arrives (between September and May) and allows it to cope with the variability in timing of inundation common to semi-arid areas. There is therefore a maximum period between inundation which if exceeded would severely affect the wild rice due to its use of resources, stored energy and water to carry out the life cycle during dry periods. (It was previously thought that during dry years, the wild rice lay dormant waiting for a flood and then went through its life cycle once the flood had arrived.) According to Marneweck (pers.comm.), the wild rice comes under serious stress after approximately three years of continuous drought with the population becoming fragmented, old rhizomes becoming moribund and a loss of dominance as a species on the floodplain. This is investigated in Section 8.7.

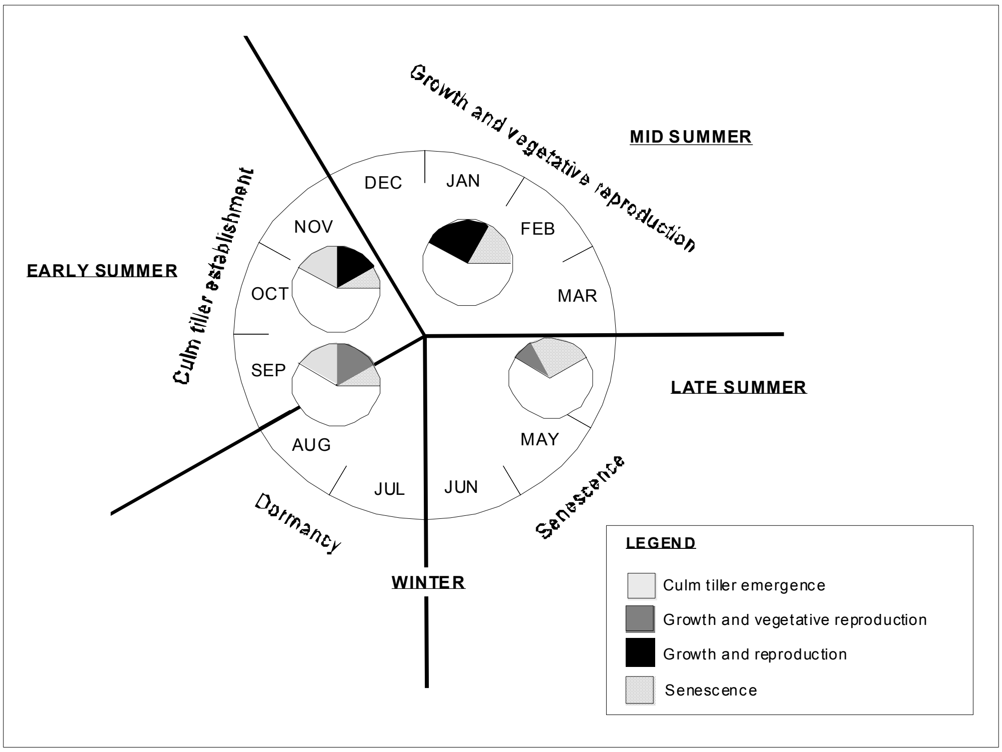

Figure 8.1: Conceptual model of the periodicity of the life history response of *Oryza longistaminata* (after Marneweck, 2003)

8.3 Comparison of stream hydrographs and inundated areas with Tarboton's observations

Dr Warwick Tarboton (a famous South African ornithologist who resides on the farm Beestepoort near the Nylsvley Reserve) has been keeping annual, qualitative records of flooding on the Nylsvlei floodplain since 1960/61 (Morgan, 1996; Tarboton, 1987). As there is a lack of flood data available before 1996 in the study area (excepting the DWAF gauges at Deelkraal (A6H002) and Mosdene (A6H013) that date back to 1922 and 1971 to 1977 respectively), this qualitative record is an important source of flooding data.

For each hydrological year, Tarboton recorded the flood timing, extent and duration based on his own observations and where these were not comprehensive, he supplemented them with the observations of other residents at Nylsvlei (Morgan, 1996). The timing of floods was described in terms of three qualitative periods: those beginning in November were classified as early, December or

January as midseason and February or March as late (Tarboton, 1989). The duration of the flood was described as either ‘no flood’, ‘brief’ or ‘sustained’. A fifty-day threshold (the time required by the colonial heron to complete its breeding cycle) was defined between a brief and a sustained flood (Tarboton, 1989). Flooding extent was classified as extensive if flooding extended past the Crecy road, moderate if flooding extended past the Vogelfontein road, and limited if flooding extended past the Deelkraal – Nylsvley road (Tarboton, 1989) as shown in Figure 8.2. Tarboton’s qualitative flood records are shown in Table 8.1.

Table 8.1: Tarboton’s qualitative flood classification record (after Morgan, 1996; Tarboton, 1989)

Season	Flood extent	Flood duration	Flood timing
1973/74	Extensive	Sustained	Early
1974/75	Extensive	Sustained	Midseason
1975/76	Extensive	Sustained	Early
1976/77	Moderate	Brief	Early
1977/78	Extensive	Sustained	Midseason
1978/79	No Flood		
1979/80	Moderate	Sustained	Early
1980/81	Moderate	Brief	Early
1981/82	Moderate	Brief	Midseason
1982/83	No Flood		
1983/84	Limited	Brief	Early
1984/85	No Flood		
1985/86	No Flood		
1986/87	Moderate	Brief	Early
1987/88	Extensive	Sustained	Early
1988/89	Limited	Brief	
1989/90	Limited	Brief	
1990/91	Extensive	Sustained	Late
1991/92	No Flood		
1992/93	No Flood		
1993/94	Limited	Brief	Late

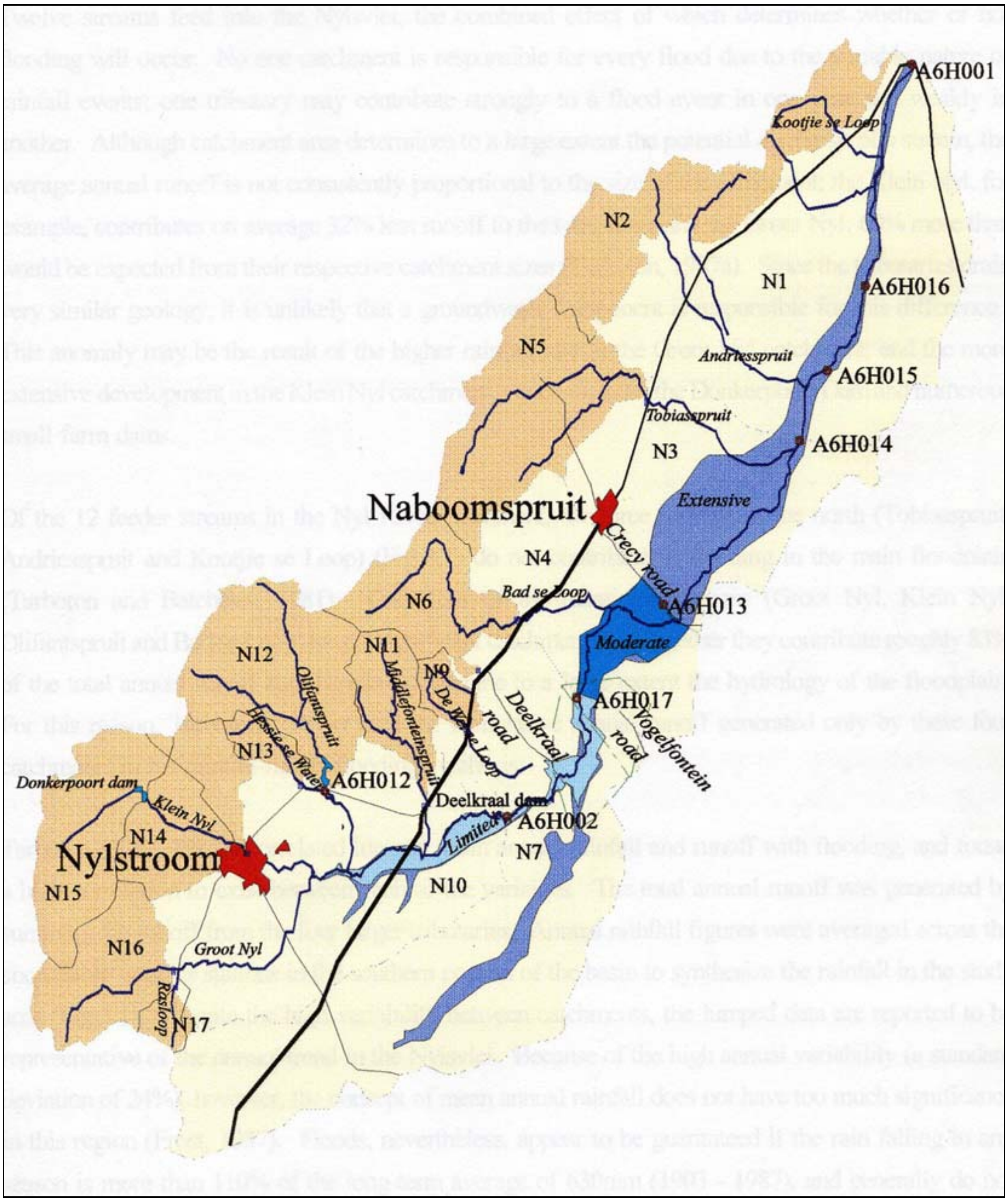

Figure 8.2: Map showing Tarboton's inundation extent definitions (from Morgan, 1996)

Tarboton's qualitative flooding records were compared with the historical catchment scenario inundation areas (in a daily time series from 1973 to 2001) of the entire study area, as an additional verification of the hydrological and hydraulic models. Daily inundation areas for each reach were obtained from the inflow-inundated area relationships (equations 6.1 to 6.3) and summed to obtain the daily total inundation area for the whole study region. Inflows required to find these areas were obtained from the run of the historical scenario in the hydraulic model. The daily series of inundated areas for the entire study region together with Tarboton's qualitative flooding descriptions are shown in Figure 8.3.

Figure 8.3 shows reasonable agreement between historical scenario modelled areas and Tarboton's descriptions, although there are years when the agreement is poor as Tarboton's descriptions are of a qualitative nature while the modelled areas are of a quantitative nature. Tarboton's descriptions are dependent on a few visual assessments at different points on the floodplain and are at a very coarse resolution. For example, a limited flood was defined as extending past the Deelkraal-Nylsvley road, thus floods that did not extend this far but inundated the Middelfontein reach may have been recorded as 'No Flood'. The hydraulic and hydrological models are also subject to errors such as in the survey, calibration, area-inflow relationship, accounting for losses to evapotranspiration, infiltration and ponding, ungauged catchments (where no calibration took place), and the extreme variability in spatial extent and intensity of storms in the region.

A rough quantitative classification of Tarboton's flood extent descriptors was possible using Figure 8.3: floods of greater than 40 km^2 could be classified as 'moderate' or 'extreme', floods between 14 km^2 and 40 km^2 could be classified as 'limited' or 'moderate', and floods less than 14 km^2 could be classified as 'no flood'.

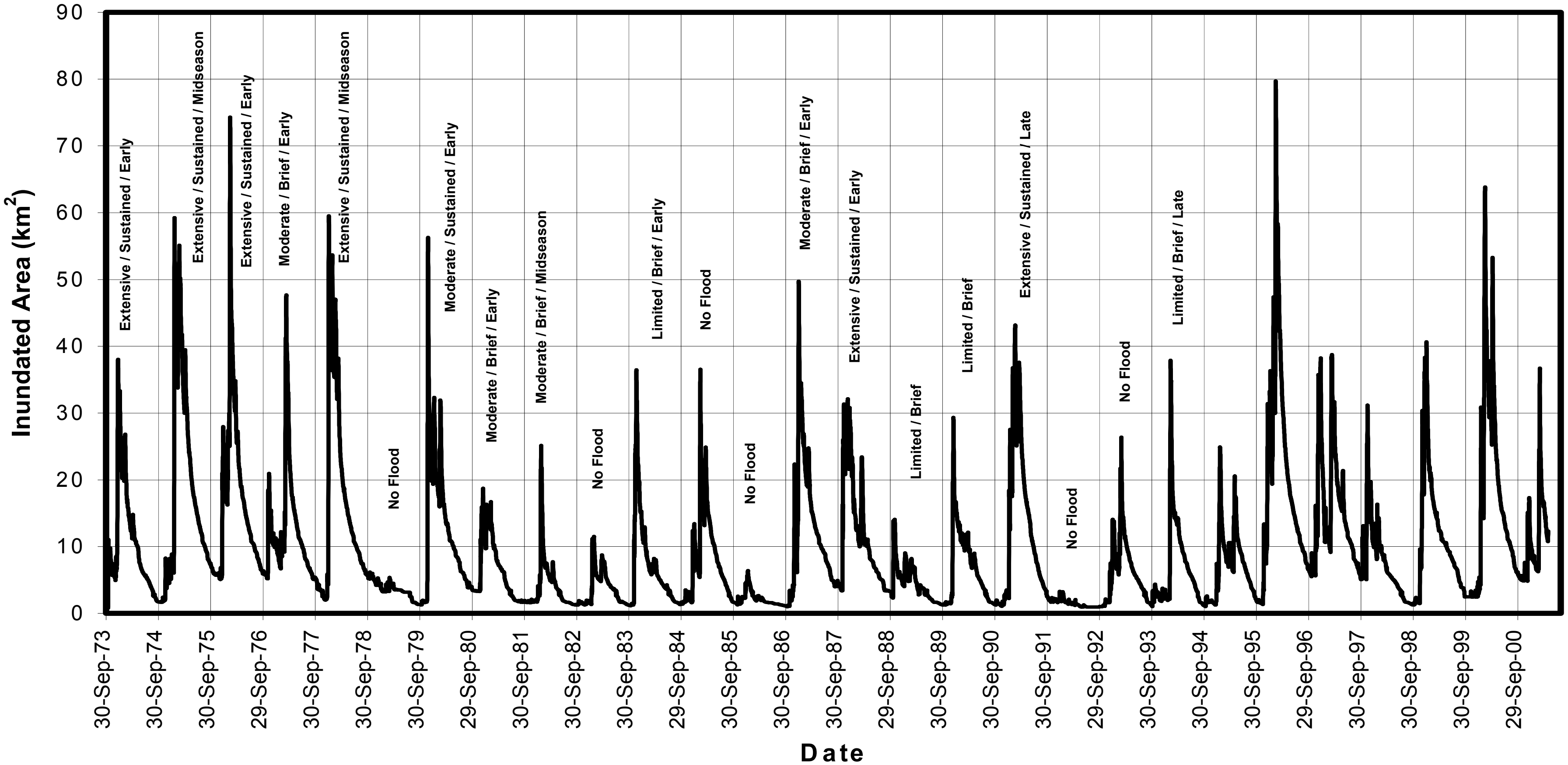

Figure 8.3: Daily time-series of inundated areas for the whole study area from the historical catchment scenario and Tarboton's qualitative flooding descriptions

8.4 Scenario predictions for temporal occurrence of inundation in the Nylsvley Reserve reach

The effects the various scenarios would have on the temporal occurrence of inundation were investigated through the derivation of curves similar to flow-duration curves, in the form of inundation area exceeded - temporal occurrence curves for the Nylsvley Reserve reach – the most important reach ecologically. The period 1 October 1973 to 30 September 1990 was analysed so that all scenarios could be included, as data for the Olifantspruit Dam with IFR releases for Ecological Management Class C scenario was limited to this period.

Daily inundation areas in the Nylsvley Reserve reach were calculated using the hydraulic model and the inflow-inundated area relationship (equation 6.2) and analysed for the number of days in the record period that certain inundation areas were exceeded. This is shown in Figure 8.4.

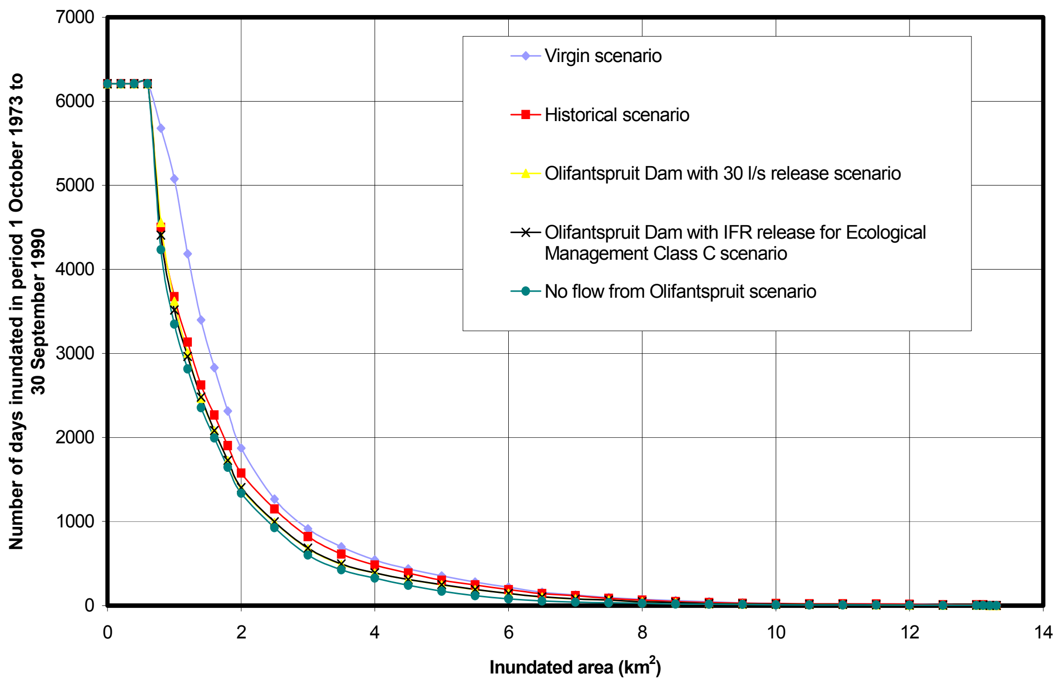

Figure 8.4: Temporal occurrences of inundation areas exceeded in the Nylsvley Reserve reach for each catchment development scenario

The difference between scenarios in Figure 8.4 was obvious for small inundation areas but not for larger inundation areas, therefore the data were expressed in terms of the virgin and historical scenarios as shown in Figure 8.5 and Figure 8.6.

The historical scenario showed a decrease in flooding occurrence compared to the virgin scenario of up to 28% except for large inundation areas where occurrences exceeded those of the virgin scenario. Reasons for this include changes in flood timing and increases in flood peak absorption by dams, changes to runoff characteristics caused by urban developments and water abstractions for irrigation and domestic use. The two Olifantspruit Dam scenarios had similar inundation area exceeded - occurrence characteristics suggesting a small difference in impact due to different release regimes. These scenarios showed decreasing flood occurrences with increasing inundated areas exceeded compared to the virgin and historical scenarios, due to the flood absorption effect of the Olifantspruit Dam (compared to the virgin and historical scenarios) in addition to the reasons listed for the historical scenario (compared to the virgin scenario). These two scenarios suggest that construction of the Olifantspruit Dam would have had a significant impact on the temporal occurrence of large inundation areas. The temporal occurrence of an inundation area larger than 12 km^2 for example, would have been reduced by 60 to 67% compared to the virgin and historical scenarios depending on the outflow regime. The no flow from the Olifantspruit scenario demonstrates this tributary's importance to flood occurrences on the floodplain, as shown by decreasing inundation occurrences with increasing inundation areas exceeded, which can be as little as 22% of the occurrence in the historical scenario for an inundation area larger than 13.1 km^2.

The apparent increase in scatter of inundation occurrences with increasing inundation area exceeded is due to the decreasing size of the data set, for example inundation areas larger than 12 km^2 occurred fifteen days or less (depending on the scenario) during the study period. Inundation occurrences were equal to the study duration at inundation areas exceeded less than 0.6 km^2 due to the artificial minimum flow of 0.1 m^3/s used in the model to maintain stability.

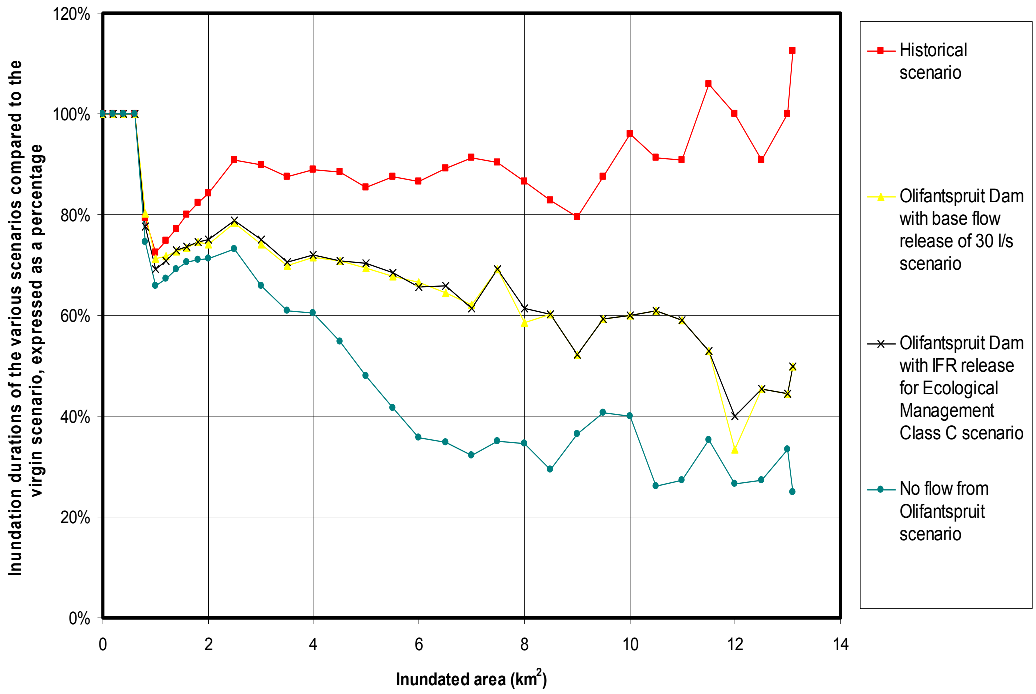

Figure 8.5: **Temporal occurrence of inundation areas exceeded in the Nylsvley Reserve reach compared to the virgin scenario**

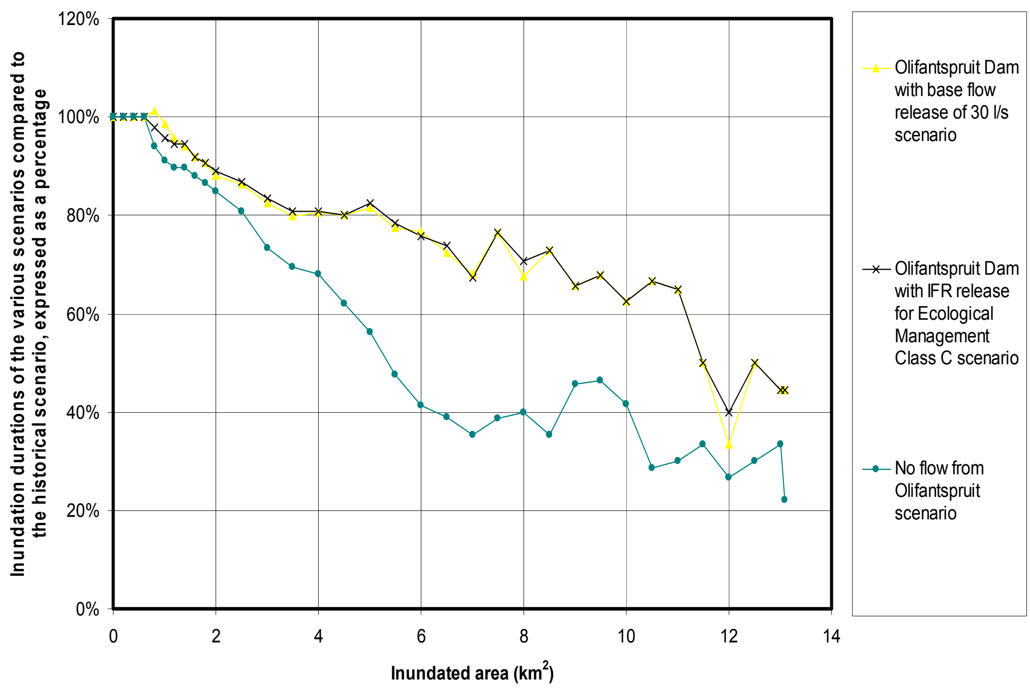

Figure 8.6: **Temporal occurrence of inundation areas exceeded in the Nylsvley Reserve reach compared to the historical scenario**

8.5 Scenario predictions for inundation areas of the duration preferred by wild rice

The effects of the catchment development scenarios on floodplain inundation areas were analysed in terms of a major requirement of the wild rice: the wild rice needs at least 25 days of inundation during January or February and more in other months to flower and set seed. The analysis was conducted by calculating daily inundation areas using the hydraulic model and inflow-inundated area relationships for each reach (equations 6.1 to 6.3) and determining the maximum area inundated continuously for 25 days in each year for each scenario over the study period ('required inundated area'). Larger areas would have been inundated for shorter periods but these would not have satisfied this duration requirement. These areas are plotted in Figures 8.7 to 8.10. The Olifantspruit with IFR releases only had data available for 1973/74 to 1989/90, this being the period for which IFR flow data were provided by the Desktop IFR Study.

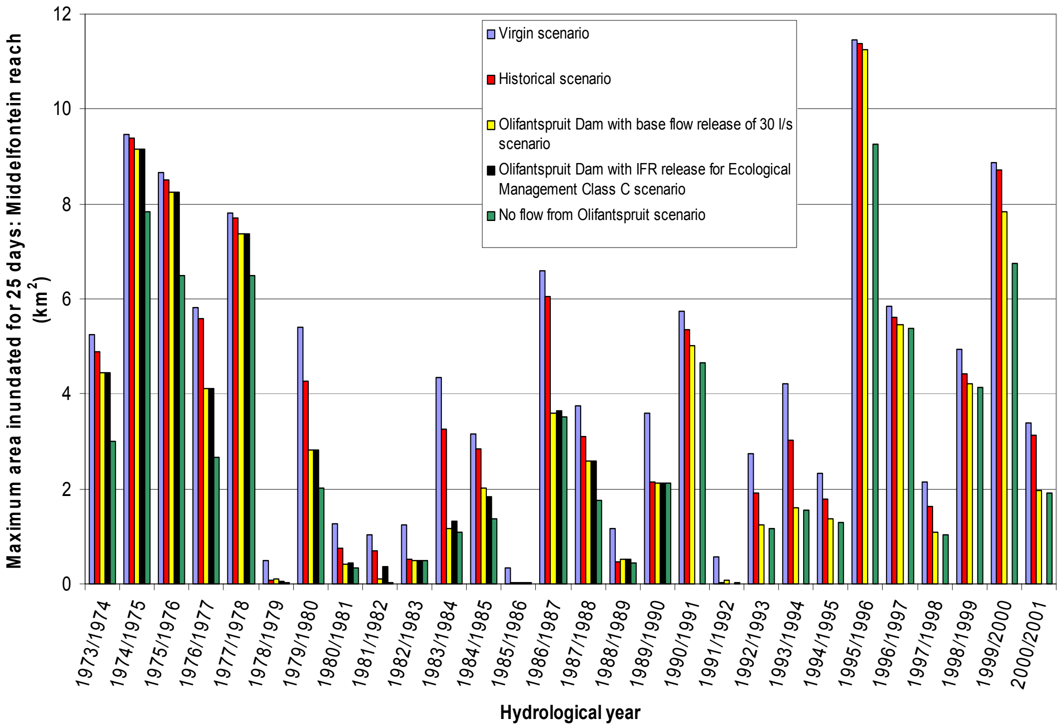

Figure 8.7: The largest areas inundated for 25 continuous days, for each year and scenario in the Middelfontein reach

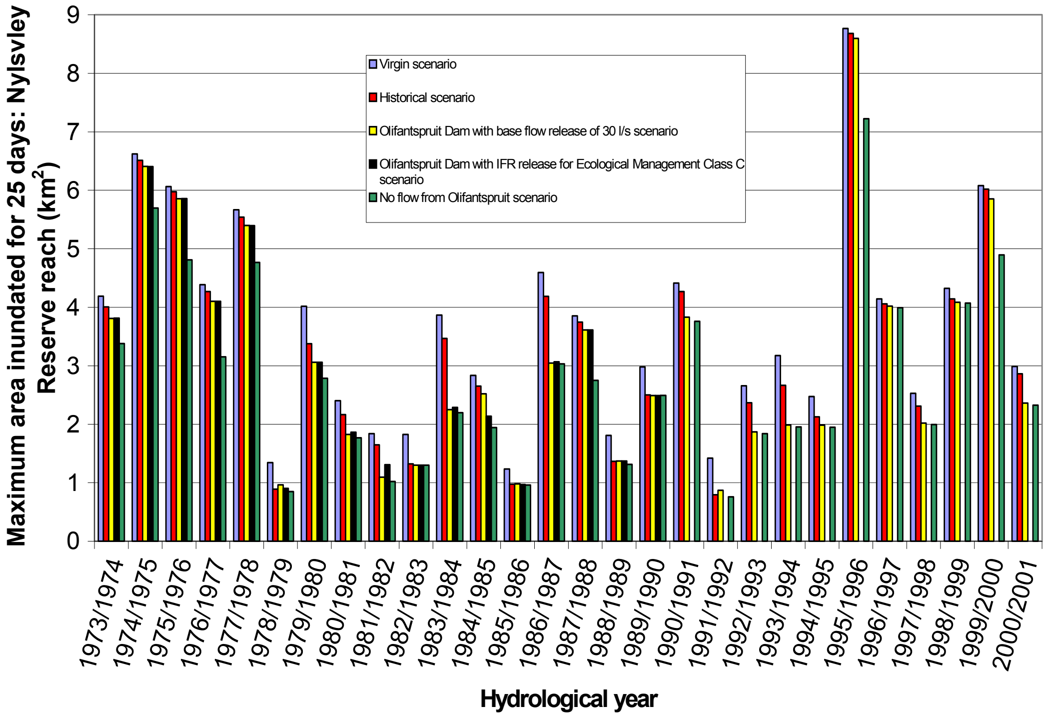

Figure 8.8: The largest areas inundated for 25 continuous days, for each year and scenario in the Nyslvley Reserve reach

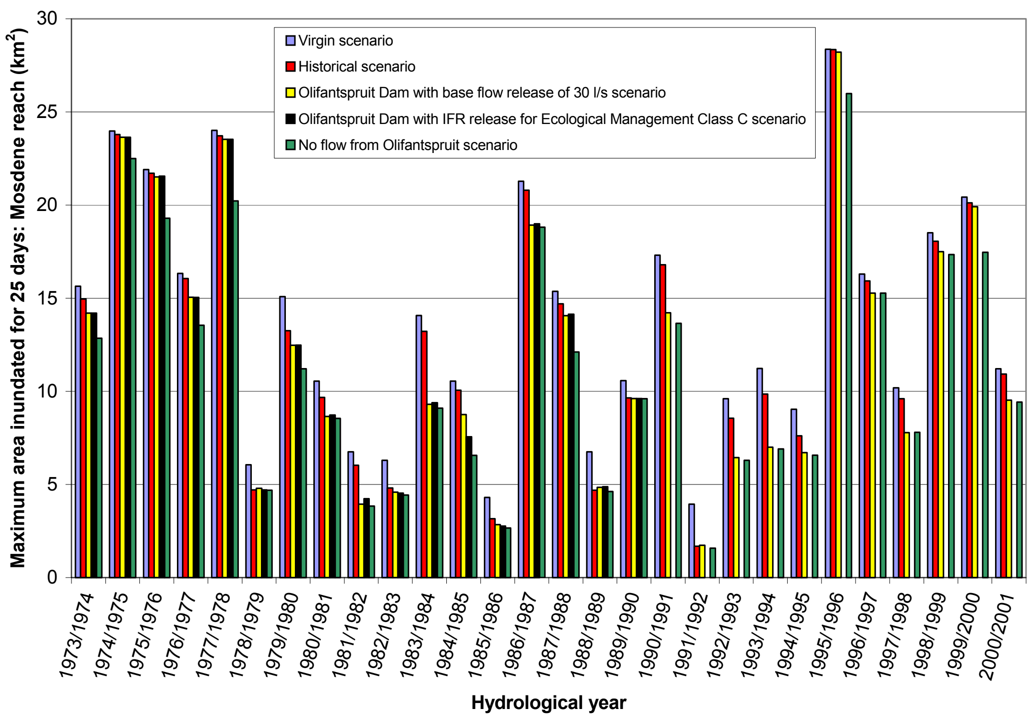

Figure 8.9: The largest areas inundated for 25 continuous days, for each year and scenario in the Mosdene reach

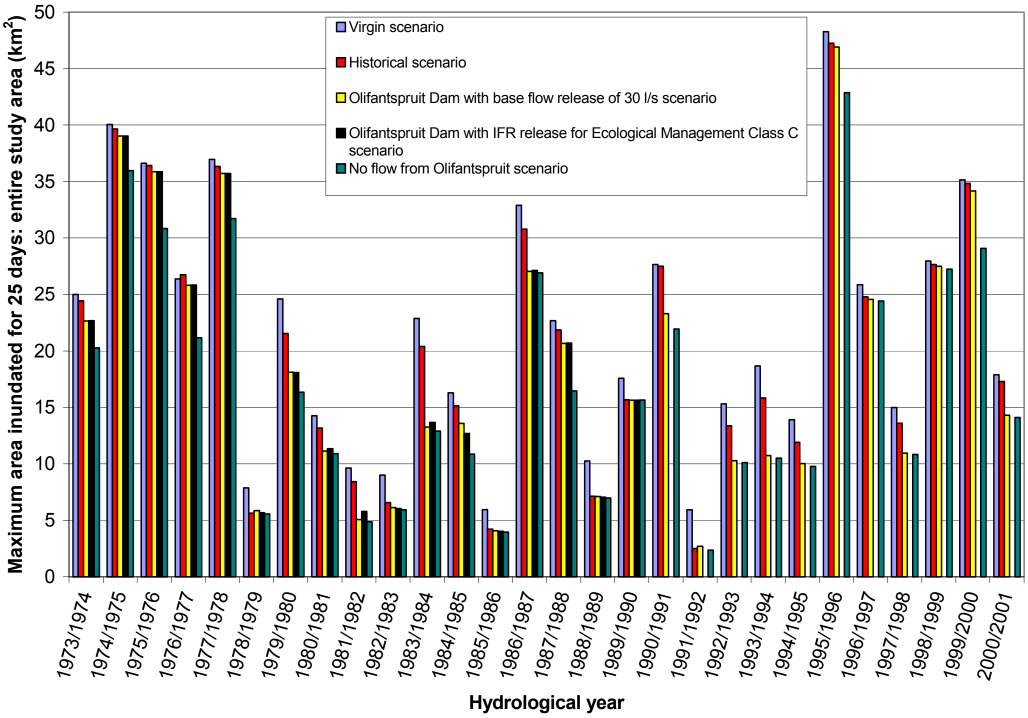

Figure 8.10: The largest areas inundated for 25 continuous days, for each year and scenario in the entire study area

A comparison of the historical and virgin scenarios shows that existing catchment developments (such as farm and other dams, irrigation schemes, urban developments) have had an impact on floodplain inundation. Their impact is not severe in wet years (for example a negligible impact is evident for all reaches in 1999/2000), but in drier years the impact is more pronounced (for example a reduction in required inundated areas of 22% was evident for 1985/86 in the Nylsvley Reserve reach). Reasons for this include differences in initial dam levels (which control flood absorption - dams tend to be full in wet years reducing their impact compared to dry years) and the greater relative impact of abstractions to for example, irrigation schemes in dry years. On average, the required inundated areas were reduced by between 7% and 12% (depending on the reach) with the historical compared to the virgin scenario (Table 8.2). The required inundated area for the entire study area in the historical scenario exceeded that of the virgin scenario in 1976/77 yet was less for each of the separate reaches. This is due to the method used to determine required inundated areas, where the maximum inundated areas for 25 days for the reaches ended on dates varying between 29 and 31 March 1977. Reasons for the historical required inundation area exceeding the virgin required inundation area in the entire study region (both ending on 30 March 1977) include impacts of urban developments.

The two Olifantspruit Dam scenarios yielded similar required inundation areas except in some dry and 'normal' years when there were differences due to the varying releases from the IFR scenario. Both scenarios had a greater negative impact on required inundation areas during dry years than wet years (compared to the historical and virgin scenarios) with the greatest impact occurring during years ('dry' or 'normal') when the Olifantspruit Dam was nearly empty initially and no spill took place. For example in the 'normal' year of 1983/84 (when the flood arrived early in the season during December), a nearly maximum reduction in required inundation areas for both release scenarios of approximately 35% and 42% compared to the historical and virgin scenarios respectively, occurred in the Nylsvley Reserve. This can be compared to a reduction in required inundated area of 37% and 43% compared to the historical and virgin scenarios respectively when no flow was contributed by the Olifantspruit. The dam also had a small positive impact on required inundation in a few years (compared to the historical scenario) due to the IFR or base flow releases. For example an increase in required inundated area of 1% occurred in the Nylsvley Reserve reach during 1985/86, and other years with significant increases in required inundated areas include 1978/79, 1988/89 and 1991/92. Thus, the impact of the dam on required floodplain inundation can be ameliorated to some extent through careful operation. On average, the Olifantspruit Dam reduced the required inundated areas by 7% to 16% in the 30 l/s constant release scenario (average of 1973/74-2000/01) and 9% to 24% in the IFR release scenario (average of 1973/74-1989/90), depending on the reach (Table 8.2). On average over the period 1973/74 to 1989/90, the constant release of 30 l/s scenario gave slightly larger required inundated areas in the Nylsvley Reserve and Mosdene reaches and slightly smaller required inundated areas in the Middelfontein reach and entire study area, than the IFR release scenario. The IFR release scenario resulted in better average dam levels at the Olifantspruit Dam.

The relative contribution of the Olifantspruit to inundation on the floodplain was generally smaller in wet years than dry years (shown by the no flow from the Olifantspruit scenario) showing that the Olifantspruit is an important tributary for inundation on the floodplain during dry (especially) and certain wet years. On average (1973/74-2000/01) the Olifantspruit contributed to the required inundation areas: 29% and 37% in the Middelfontein reach, 18% and 24% in the Reserve reach and 19% and 13% in the Mosdene reach for the historical and virgin scenarios respectively. The reducing influence of the Olifantspruit with distance downstream is due to additional inflows from tributaries onto the floodplain.

Table 8.2: Average maximum areas (for 1973/74-2000/01) inundated for at least 25 continuous days for each reach (km^2)

Reach	Virgin	Historical	Olifantspruit Dam with constant 30 l/s release	Olifantspruit Dam with IFR release (average for 1973/74-1989/90)	No flow from Olifantspruit
Entire area	21.8	20.4	18.7	18.1	17.2
Middelfontein	4.3	3.8	3.2	2.9	2.7
Nylsvley Reserve	3.7	3.4	3.1	2.9	2.8
Mosdene	13.8	12.9	12.0	11.8	11.2

8.6 Scenario predictions for temporal occurrence of inundation areas of duration preferred by wild rice

The temporal occurrence of exceedence of the largest area inundated for at least 25 continuous days in each year are shown for each reach in Figures 8.11 to 8.14. These occurrences were calculated using the maximum areas inundated for 25 days in each year for 1973/74 to 1989/90 plotted in Figures 8.7 to 8.10. The period 1973/74 to 1989/90 was analysed so that all scenarios could be included (Chapter 7).

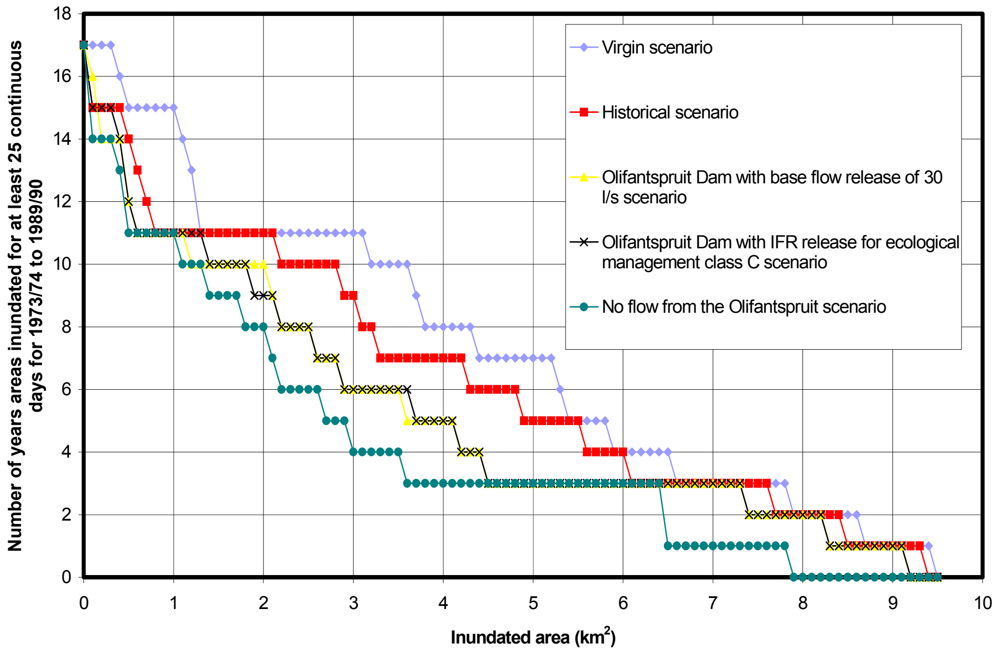

Figure 8.11: Number of years in which different inundation areas of at least 25 continuous days duration were exceeded for the different scenarios in the Middelfontein reach

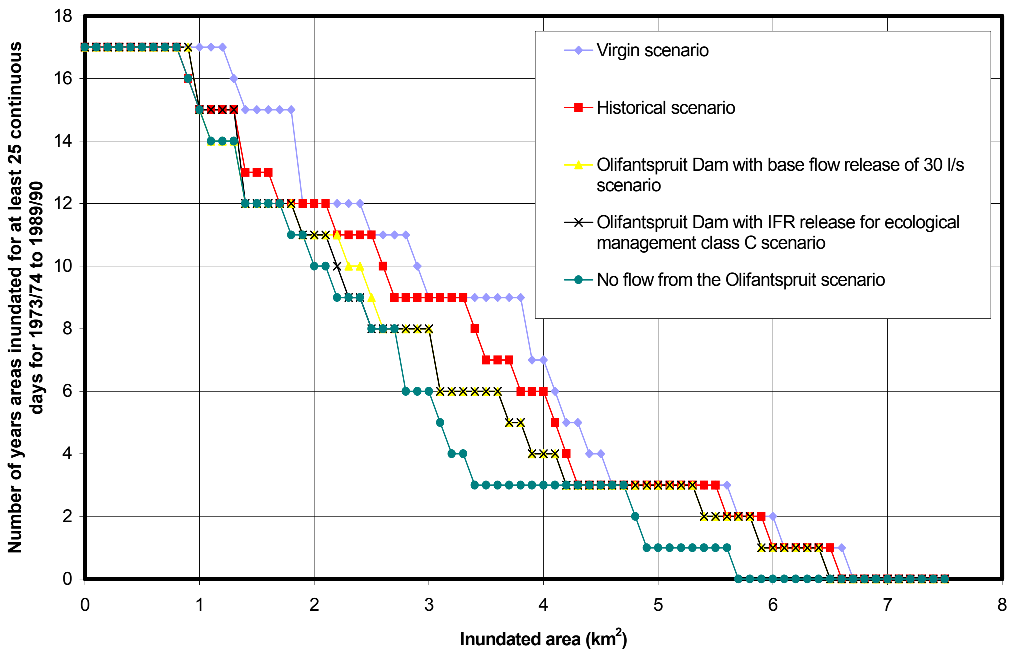

Figure 8.12: Number of years in which different inundation areas of at least 25 continuous days duration were exceeded for the different scenarios in the Nylsvley Reserve reach

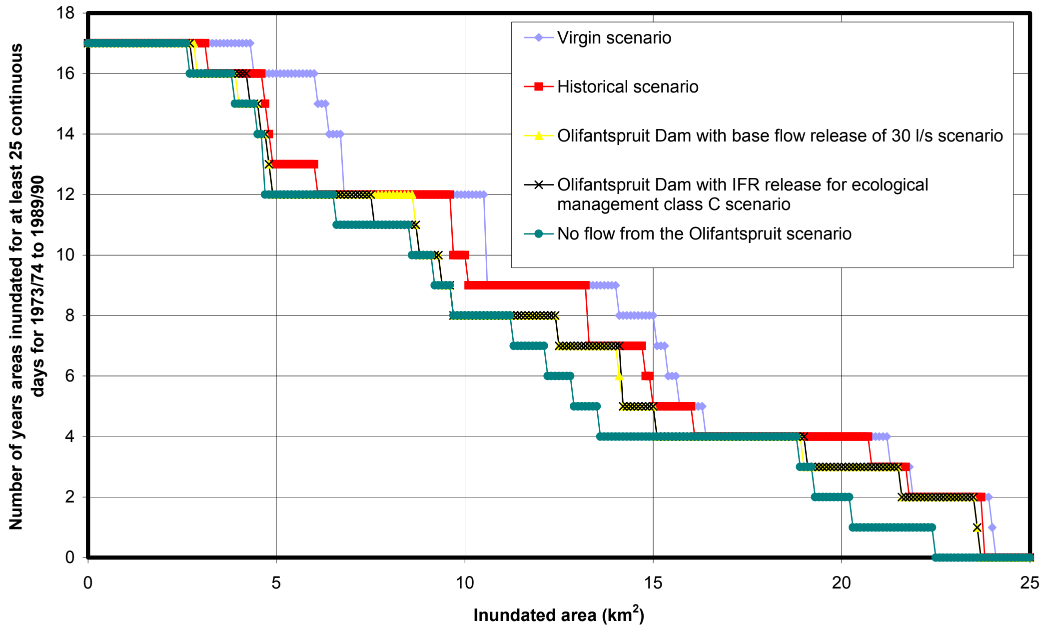

Figure 8.13: Number of years in which different inundation areas of at least 25 continuous days duration were exceeded for the different scenarios in the Mosdene reach

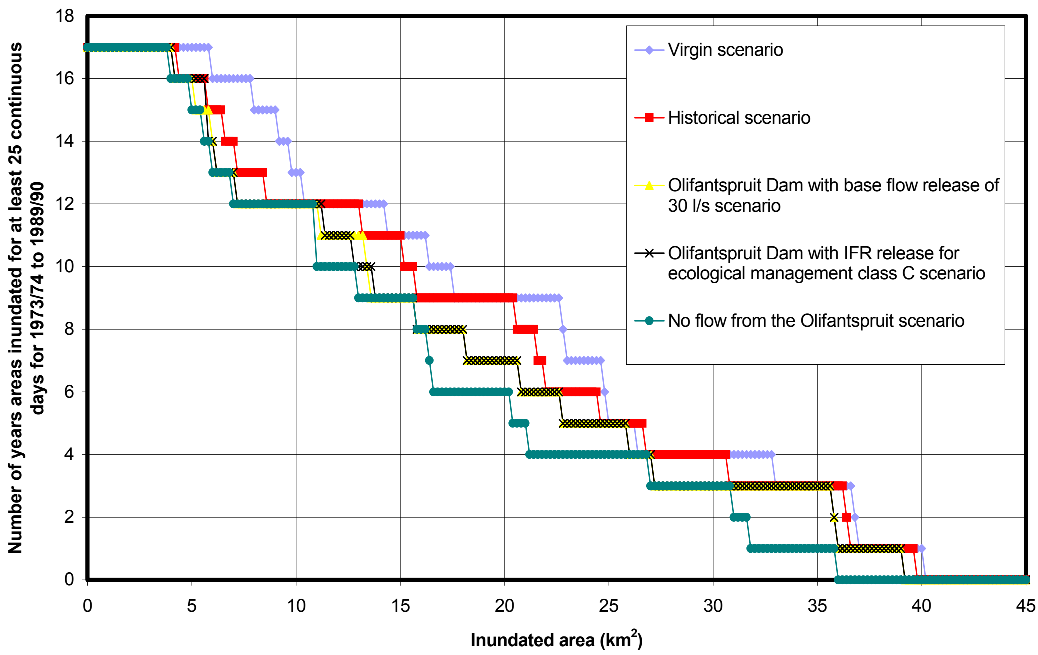

Figure 8.14: Number of years in which different inundation areas of at least 25 continuous days duration were exceeded for the different scenarios in the entire study area

The stepped nature of the graphs is due to the limited number of data points – 17 years consisting of one data point each, and the years being counted as integer values. The minimum inundated area was not zero in the Nylsvley Reserve and Mosdene reaches (and consequently for the entire area) due to the nature of their inflow-inundated area relationships (equations 6.1 to 6.3) and the artificial minimum flow of 0.1m^3/s used in the model to maintain stability.

A decrease in occurrence of required inundation duration for wild rice with increasing catchment development is evident in Figure 8.11 to Figure 8.14. The two Olifantspruit Dam release scenarios resulted in very similar occurrences of inundation areas, excepting a few times when the 30 l/s scenario performed better.

8.7 Scenario predictions for inundation areas of duration and depth preferred by wild rice and their temporal occurrences in the Nylsvley Reserve reach

The wild rice (as described previously) has specific inundation depth requirements for optimum growth of between 0.1m and 0.5m, which were not included in the previous analyses. Scenario predictions for areas inundated for 25 continuous days (shown in Figure 8.17) and their occurrences in this depth range were found for the Nylsvley Reserve reach, as it is the most pristine and ecologically sensitive reach in the study area and of greatest interest to the public and other researchers.

An inflow-inundated area relationship (similar to equations 6.1 to 6.3) for this depth range was derived for the Nylsvley Reserve reach. Certain virgin catchment scenario inflows to the Nylsvley Reserve reach occurring on the recession limb of the hydrograph were selected (as this scenario gave the greatest variation in flood peak magnitudes), varying from 0.1 to 84 m^3/s (Table 8.3). Recession flows were carefully selected in periods of minimal change, representing a pseudo steady state. Inundated top widths at each cross-section were extracted from HEC-RAS for each of the dates given in Table 8.3 and input into the floodplain-mapping module within RiverCAD to map inundated areas with contours at 0.1m and 0.5m depth. This was done individually for each date and depth and was thus a time consuming process due to the many islands and areas that had to be selected individually.

Table 8.3: Inflows used to calculate inundated areas between 0.1m and 0.5m depth using RiverCAD

Date	Inflow (m^3/s)
13 February 1996	83.709
14 February 1996	66.331
15 February 1996	42.423
18 February 1996	21.652
23 February 1996	14.196
2 March 1996	9.163
10 March 1996	7.224
20 March 1996	5.185
27 March 1996	4.033
5 April 1996	3.049
21 April 1996	2.025
9 June 1996	1.005
30 August 1996	0.501
Zero Area	0.1

The data point for the 10th of March 1996 was regarded as an outlier and ignored when deriving the inflow-inundated area function. The inundated area was set to zero at a flow of 0.1 m^3/s. The derived function (shown in Figures 8.15 and 8.16) consists of two parts, both with a goodness of fit (R^2) value better than 0.99:

$$A = -1.081807I^2 + 2.696902I - 0.258872 \qquad (I \leq 1.005)$$

$$A = -0.000002I^4 + 0.000372I^3 - 0.027323I^2 + 0.696459I + 0.687850 \qquad (I > 1.005) \qquad (7.1)$$

Where A is the inundated area with depth between 0.1m and 0.5m in km^2 and I is the inflow in m^3/s.

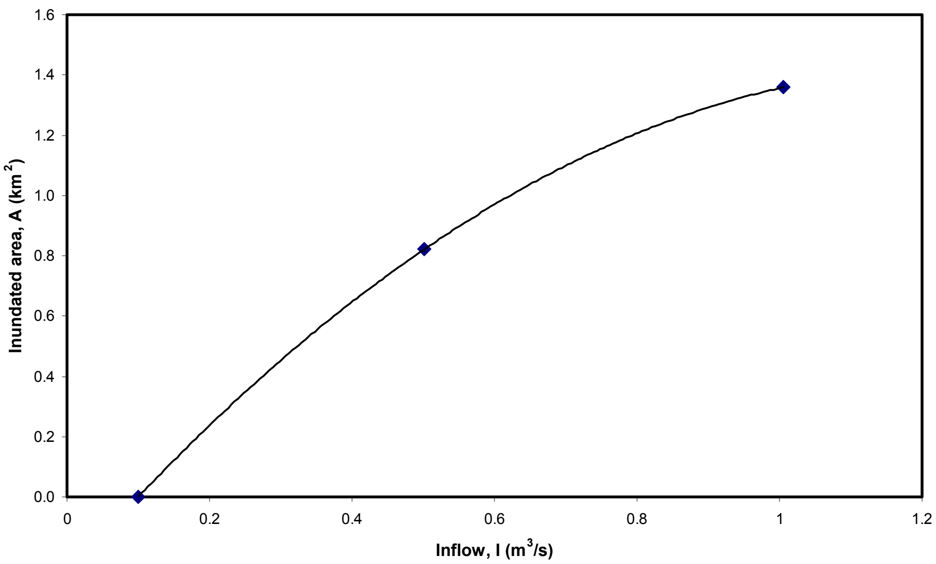

Figure 8.15: Inflow, *I*, (m^3/s) versus inundated area with depth between 0.1m and 0.5m, *A*, (km^2) regression for range $0.1 \leq I \leq 1.005$

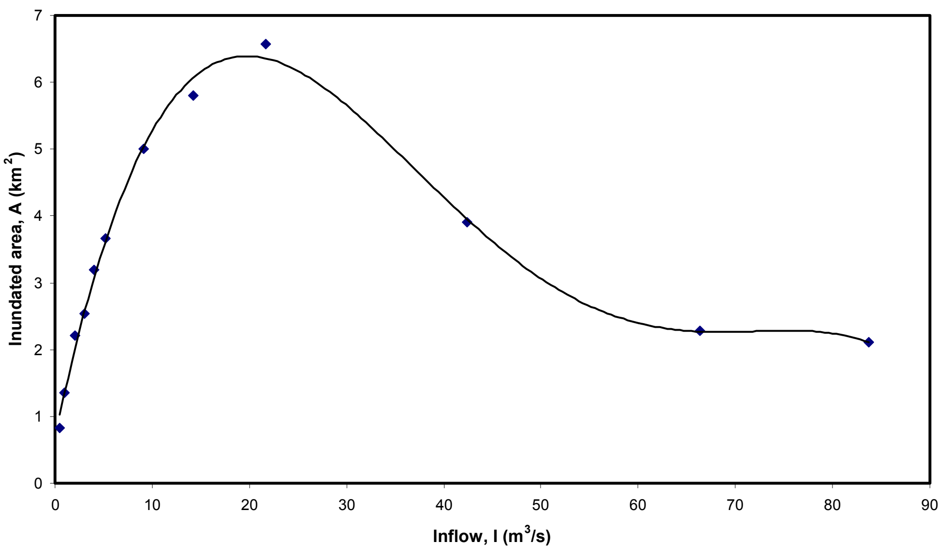

Figure 8.16: Inflow, *I*, (m^3/s) versus inundated area with depth between 0.1m and 0.5m, *A*, (km^2) regression for range $I > 1.005$

The decrease in inundated area of suitable depth with increasing inflows larger than 20 m^3/s is due to increasing areas being inundated to depths greater than 0.5m (mainly flat floodplain areas near the channel). The largest inundated areas for the specific depth requirements of the wild rice occurred at an inflow of approximately 20 m^3/s (Figure 8.16) in the Nylsvley Reserve, due to the valley shape. However, this magnitude of flow never occurred for long enough during the record period for the wild rice to grow in these higher elevation areas. The largest area inundated historically in this optimum depth range was 4.25 km^2 in 1995/96 (Figure 8.17), which corresponds to an inflow of approximately 6.7 m^3/s. This inundated area corresponds to about half the total inundated area for 25 days with no depth limits for the same flow, of 8.77 km^2.

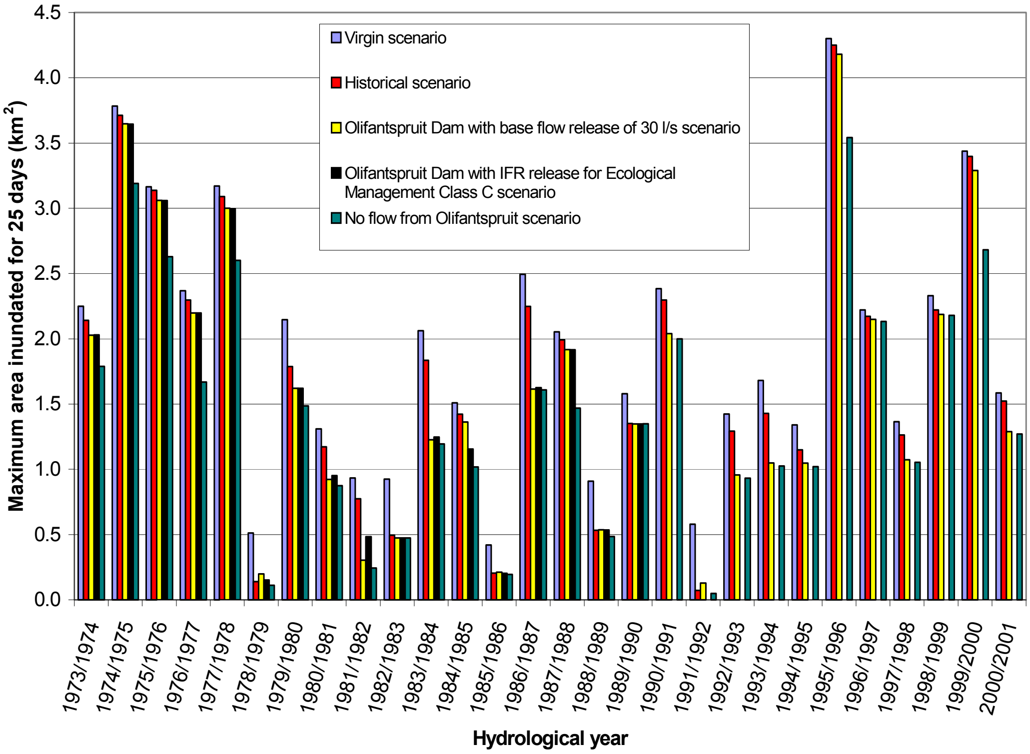

Figure 8.17: The largest areas inundated for 25 days at depths between 0.1m and 0.5m, for each year and scenario for the Nylsvley Reserve reach

Again, the largest differences between the virgin and historical scenarios occurred during dry years while during wet years they were often small, due to catchment developments such as dams and irrigation schemes. An extreme example is the severe drought of 1991/92 when suitable inundated areas were reduced by 87%, although on average (1973/74-2000/01) suitable inundated areas were reduced by 9% compared to the virgin scenario. The Olifantspruit Dam with 30 l/s release reduced suitable inundated areas by 78% during 1991/92 compared to the virgin scenario but increased the suitable inundation area by 75% over that of the historical scenario, demonstrating again that careful operation of a dam could mitigate its impact in dry years. The maximum modelled reduction in suitable inundated area from a dam on the Olifantspruit in this year was 92% compared to the virgin scenario and 33% compared to the historical scenario (represented by the no flow from the Olifantspruit scenario).

On average (1973/74-1989/90) both Olifantspruit Dam scenarios resulted in the same suitable inundated area on the floodplain (1.51 km^2, 19% and 9% less than the virgin and historical scenarios respectively for the same period). The 30 l/s release scenario resulted in the largest inundated areas during drought years (also larger than the historical scenario inundated areas). Compared to the historical scenario, both dam scenarios had the greatest impact in the drought year of 1981/82 (61% and 38% reduction in suitable inundated area for the 30 l/s and IFR release scenarios respectively), when the Olifantspruit Dam was initially nearly empty. The maximum impact modelled was a 69% reduction in suitable inundated area compared to the historical scenario, showing that the Olifantspruit made an important contribution to suitable inundation areas in this year and is a very important tributary for inundation on the Nylsvlei floodplain in dry years. During wet years, the Olifantspruit made a small contribution to suitable inundation areas (approximately 2% compared to the historical scenario during 1996/97 for example). On average, (1973/74-2000/01) the Olifantspruit contributed to 18% of the suitable inundated areas on the floodplain in the historical scenario.

The temporal occurrence of exceedence of the largest areas within this depth range inundated for at least 25 continuous days in each year are shown in Figure 8.18, showing the impact of catchment development. These occurrences were calculated using the maximum areas inundated for 25 days in each year for 1973/74 to 1989/90, plotted in Figure 8.17. As stated previously, the period 1973/74 to 1989/90 was analysed so that all scenarios could be included (Chapter 7). Again, the stepped nature of the curves is due to the limited number of data points and the years being counted as integer values. Both the Olifantspruit Dam scenarios resulted in similar occurrences of suitable inundated areas. A very large dam on the Olifantspruit would have a major impact on the wild rice as shown by the extreme case of the no flow from the Olifantspruit scenario.

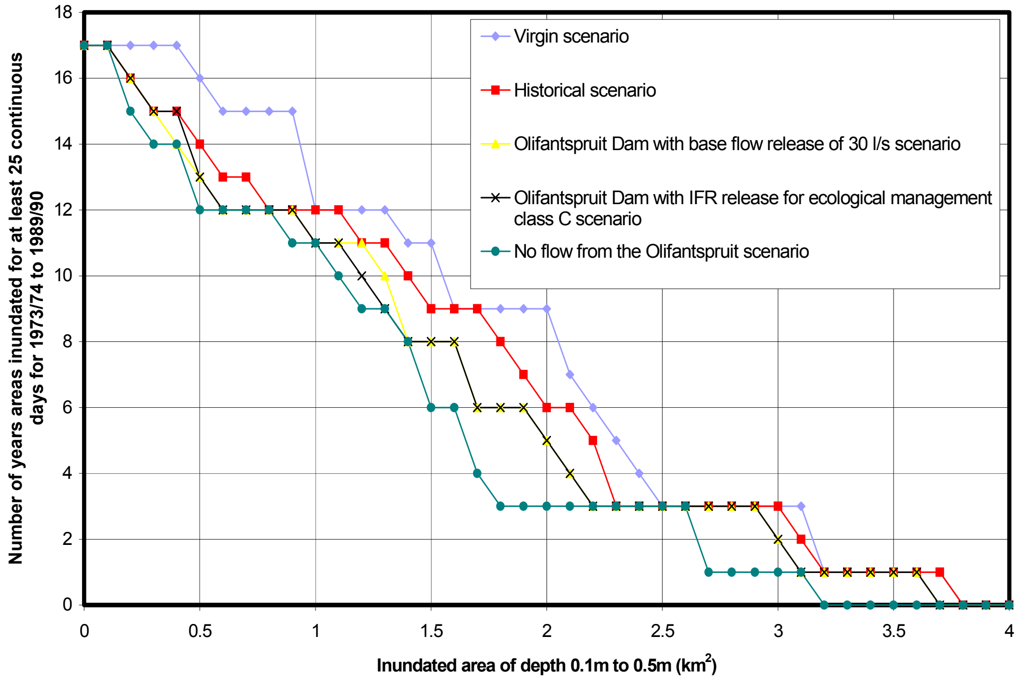

Figure 8.18: Number of years in which different inundation areas of depths between 0.1m and 0.5m and of at least 25 continuous days duration were exceeded for the different scenarios in the Nylsvley Reserve reach

As stated earlier, according to Marneweck (pers.comm.) the wild rice comes under serious stress after approximately three years of continuous drought with the population becoming fragmented, old rhizomes becoming moribund and a loss of dominance as a species on the floodplain. If three years is taken as a threshold period between floods, then on average, areas would have had to be inundated a minimum of approximately 6 times during this period to support wild rice. Based on this assumption, suitable areas for wild rice in the Nylsvley Reserve reach (with the required inundation depth range, duration and minimum frequency) have been reduced from 2.2 km^2 in the virgin scenario to 2.1 km^2 in the historical scenario and potentially to 1.9 km^2 in the Olifantspruit Dam scenarios to 1.6 km^2 with no flow contribution from the Olifantspruit.

8.8 Summary

The hydraulic and hydrological parts of the Nylsvlei model were verified against Tarboton's qualitative flood inundation data using the hydraulic model outputs of inundated areas, and generally there was reasonable agreement. The Olifantspruit Dam scenarios were found to have a significant impact on the temporal occurrence of floods, which increased with flood size. It was shown that the wild rice would be affected negatively in certain dry years by the construction of a dam on the Olifantspruit of the dimensions proposed in 1993 (Theron Prinsloo Grimsehl & Pullen Ing., 1993), with an IFR release for Ecological Management Class C or a constant base flow release of 30 l/s, although this impact could be mitigated through careful operation. It was also shown that during certain wet years, the impact of the dam on floodplain inundation and hence the wild rice would be minimal. The Olifantspruit was found to be a very important tributary during dry years for suitable inundation of the floodplain for wild rice growth, but not during wet years. Increasing catchment developments were shown to have increasing negative impacts on inundation frequency for all inundation areas.