

# Hoddles Creek Streamflow Spell Analysis

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Melbourne Water

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# 1. Introduction

This report details the spell analysis performed on Hoddles Creek streamflows at Warburton Highway (streamflow gauge 229224). This involved an analysis of spell frequency, spell duration and the seasonality of spells for flows below 4 ML/day and 7 ML/day under natural, current and full development conditions.

Sinclair Knight Merz had previously undertaken two studies as part of catchment modelling of the Hoddles Creek catchment. These were:

- The development of a water balance model for the catchment (Sinclair Knight Merz, 2000a); and
- Modelling of the effect of farm dams on streamflows in the catchment (Sinclair Knight Merz, 2000b).

The period of modelling for these previous studies was January 1965 to January 2000. Additional data was made available for this project to enable extension of the model inputs to the end of December 2000. Unless otherwise stated in this report, the methods applied in these previous studies have been adopted for extension of the data inputs for this study.

The following sections of the report detail:

- Extension of the period of catchment modelling to the end of December 2000 (Section 2)
- Spell analysis on streamflows for the Hoddles Creek catchment (Section 3).

## 2. Streamflow Data Preparation

### 2.1 Introduction

Prior to performing a spell analysis on streamflow data for Hoddles Creek, the period of analysis was extended to include recently collected data. This section of the report outlines the methods used in preparing this streamflow data. The steps involved were:

1. Preparation of climate data
2. Preparation of irrigation demand data for irrigated areas in the catchment
3. Preparation of streamflow data under natural flow conditions, current flow conditions and after full uptake of existing diversion licences.

The period of streamflow data available from previous studies was January 1965 to January 2000. This period was extended to the end of December 2000 for this study. Unless otherwise stated, the methods applied in these previous studies have been adopted for extension of the data inputs for this study.

### 2.2 Climate Data

The Bureau of Meteorology (BoM) rainfall sites at Silvan (086104) and the Melbourne Regional Office (086071) were used in this study. The rainfall data was infilled, disaggregated and de-trended as outlined in Sinclair Knight Merz (2000a). Evaporation data at Silvan (086106) and at the Melbourne Regional Office was infilled and disaggregated as outlined in Sinclair Knight Merz (2000a).

### 2.3 Irrigation Demand Data

The extended rainfall and evaporation time series were used as inputs to the previously calibrated PRIDE irrigation demand model. The model was used to produce a demand time series under historical conditions, current conditions and after full uptake of existing licences.

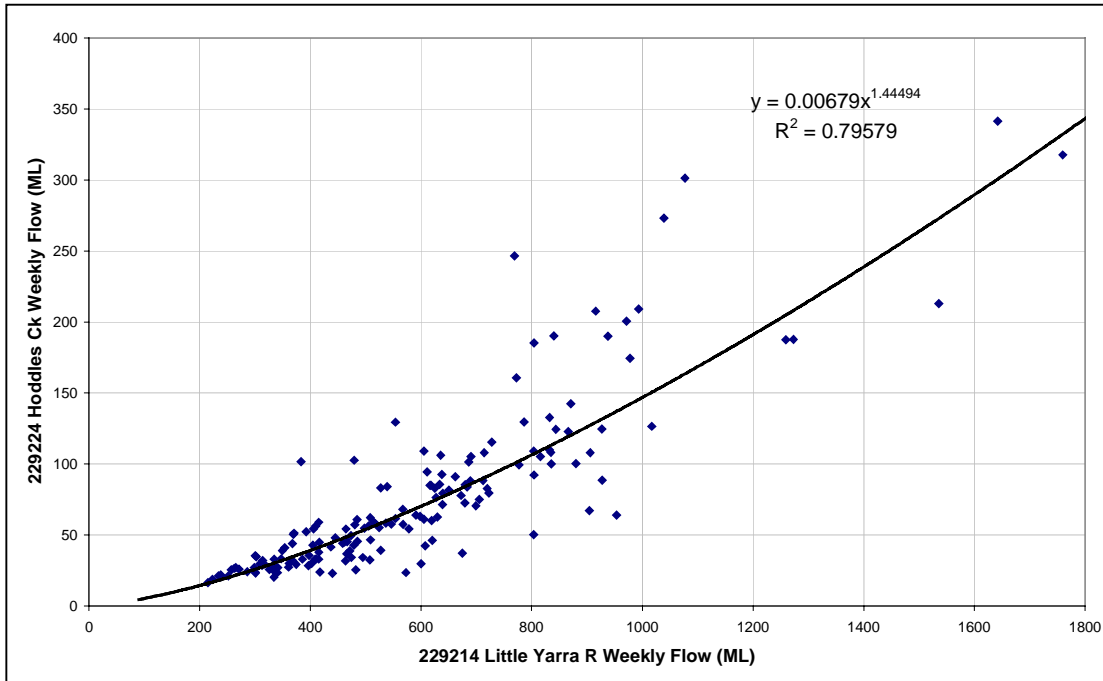
### 2.4 Streamflow Data

#### 2.4.1 Recorded Streamflow Data

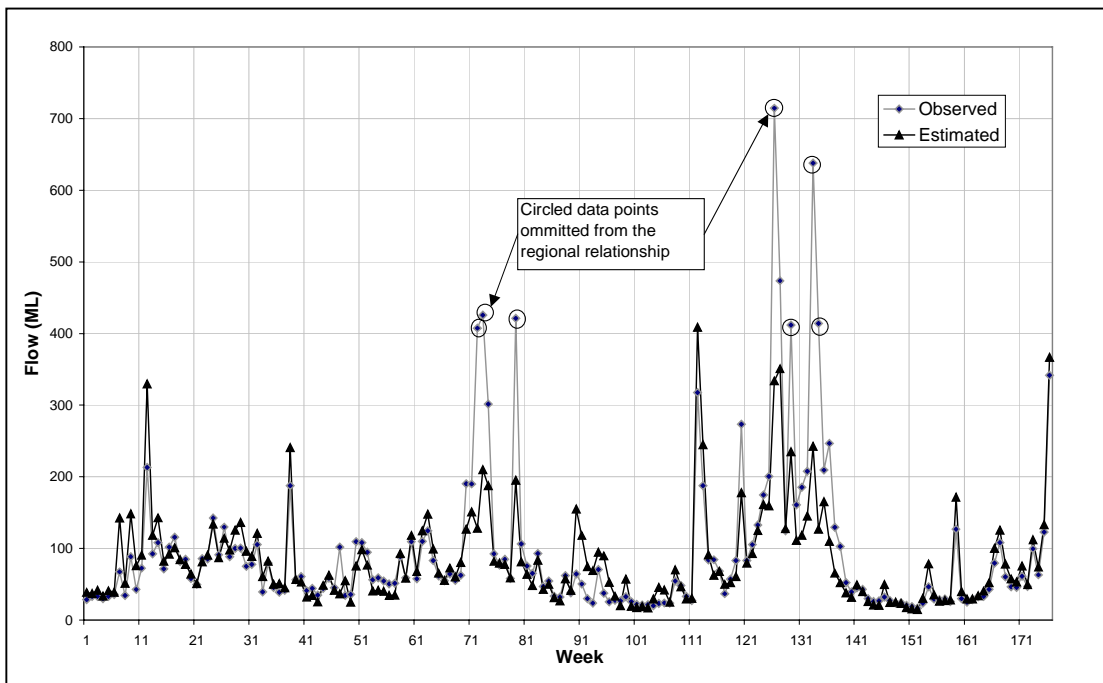
Streamflow data was collected for Hoddles Creek at Warburton Highway from April 1998 to date. The recorded streamflow data was infilled and extended to cover the period of analysis from 1965 to 2000. This was achieved using a weekly relationship between recorded streamflows for the Little Yarra River at Yarra Junction (streamflow gauge 229214) and Hoddles Creek at Warburton Highway.

The relationship previously developed in Sinclair Knight Merz (2000a) was revised to take into account the additional recorded data, as well as a recent rating table change to the Hoddles Creek gauge. The relationship is presented in Figure 2-1 and was considered suitable to adopt. Seven outliers were removed from the data set before fitting the relationship. All of the outliers were high flow events, which were removed to improve the fit to low flows. The streamflow time series and flow-duration curve for the recorded and estimated streamflow data are shown in Figure 2-2 and Figure 2-3 over the period of available recorded data.

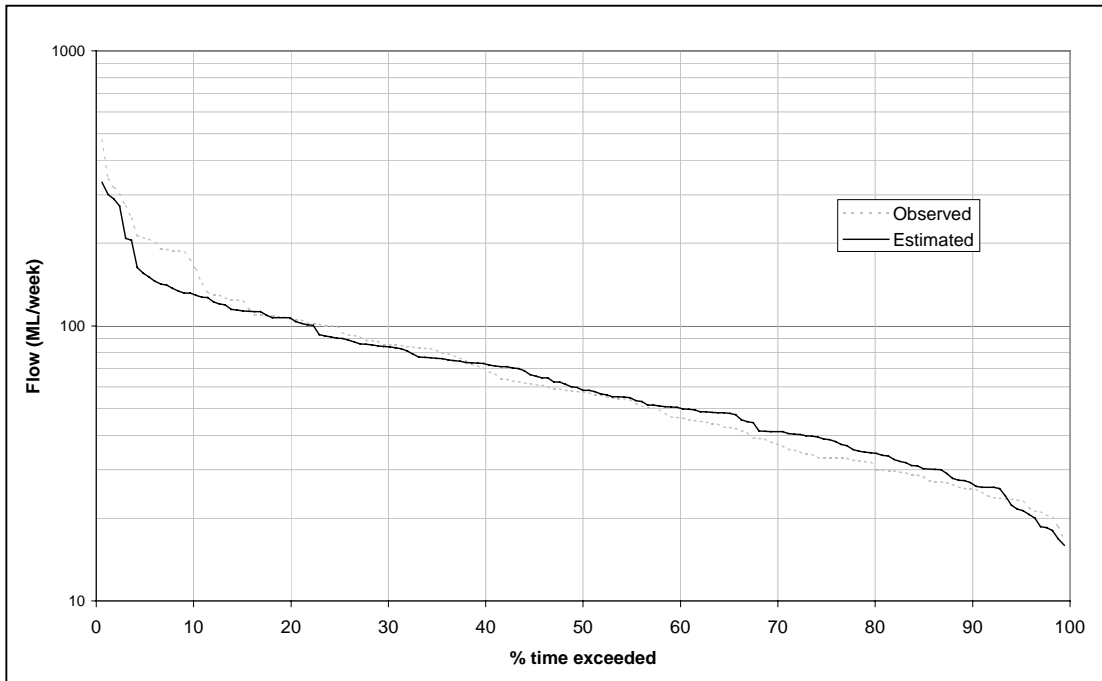
■ Figure 2-1 Relationship between weekly streamflow data at Hoddles Creek (229224) and the Little Yarra River (229214) from 3/4/1998 to 31/12/2000



■ Figure 2-2 Weekly time series of observed and estimated Hoddles Creek flows at Warburton Highway from 3/4/1998 to 31/12/2000. Circled observed points mark removed outliers.



- **Figure 2-3 Observed and estimated flow duration curves for Hoddles Creek at Warburton Highway from 3/4/1998 to 31/12/2000. Outliers were removed from the estimated curve.**



#### 2.4.2 Streamflows at Specific Levels of Development

The sub-catchment inflows prepared above were based on recorded streamflow data. In order to estimate streamflows under natural, current and full development conditions, licensed demands and the effect of farm dams needed to be taken into account.

The three scenarios investigated for this study were:

**Natural flows** – a best estimate of flows that would have occurred in an undisturbed catchment (ie no diversions and no farm dams).

**Current flows** – flows that would occur if the current level of development is applied to the 1965-2000 climatic conditions (ie current use and current volume of farm dams). This does not include inactive licences (sleepers).

**Full development flows** – flows that would occur after full uptake of licences (ie sleeper licences activated and current volume of farm dams).

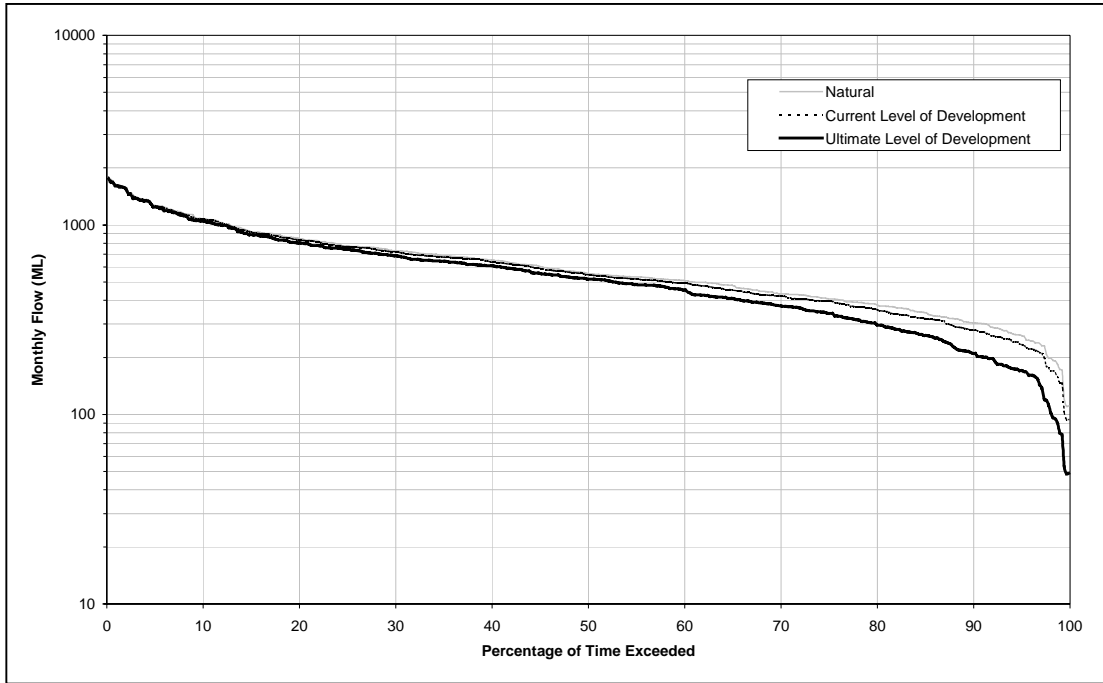
The current and full development flows were determined using the REALM water balance model with irrigation demands specified at the particular level of development. The natural flows were determined assuming no licensed diversions and then removing the effect of farm dams using the process outlined in Section 2.4.3.

#### 2.4.3 The effect of farm dams on streamflows

The Tool for Estimating Farm Dam Impacts (TEDI) was applied to the flow series containing no licensed diversions to estimate streamflows prior to any farm dam development in the catchment. The technique applied and TEDI model parameters adopted were identical to those in Sinclair Knight Merz (2000b).

The flow duration curves for Hoddles Creek with no farm dams and the current level of farm dam development are shown in Figure 2-4. The current level of farm dam development is 96 ML of dams (or 1.4% of mean annual flow). The results are very similar to those previously presented in Sinclair Knight Merz (2000b).

■ **Figure 2-4 The effect of farm dams on the flow duration curve for Hoddles Creek at Warburton Highway, 1965 to 2000**



## 3. Streamflow Spell Analysis

### 3.1 Introduction

A daily spell analysis was performed for natural, current level and full level of development flows below 4 ML/day and 7 ML/day. This section of the report is an analysis of the duration, frequency and seasonality of spells below these two trigger points.

### 3.2 Spell Definitions

A **low flow spell** is an event which occurs when flows are continuously entirely below a nominated threshold value.

The **spell duration** is the number of days when the streamflow is continuously below a given threshold.

The **spell frequency** is the number of spells which occur over a given time period.

The **seasonality of spells** can be defined by the month in which the spell commences.

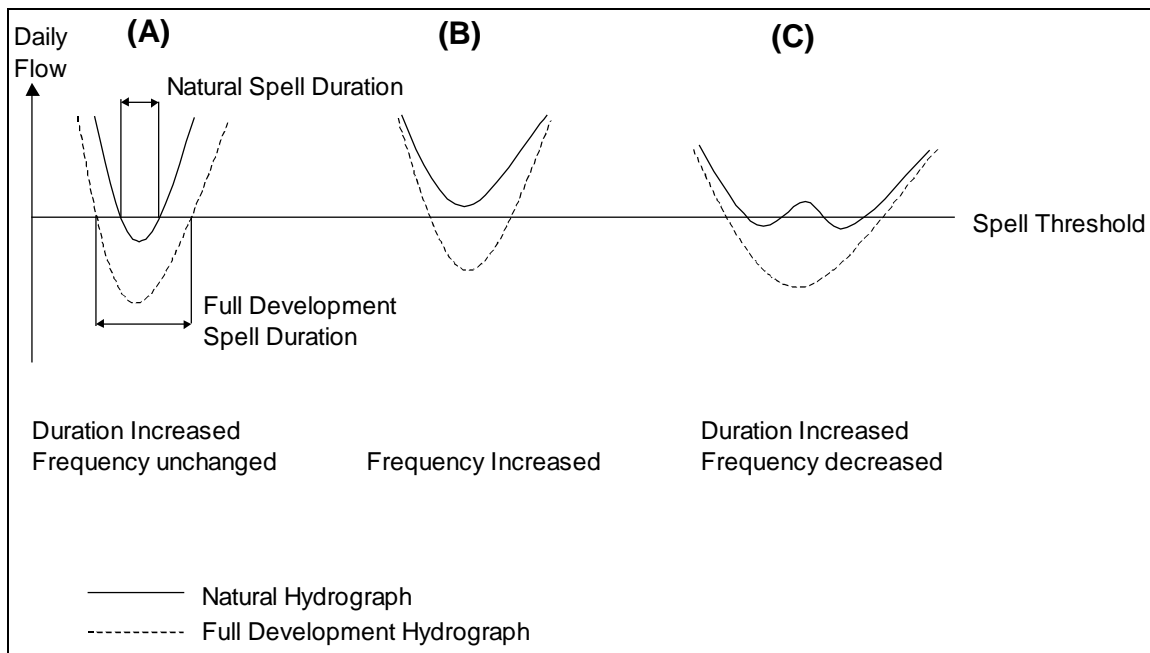
### 3.3 Understanding a Flow Spell Analysis

A reduction in streamflow caused by water diversion can result in three possible effects on low flow spells:

- The duration of an existing spell may be increased without affecting the frequency of spells in the streamflow record (Figure 3-1(A)).
- A new spell event may be created which increases the frequency of spells in the streamflow record (Figure 3-1(B)).
- Two shorter duration spell events may be merged to create a longer duration event, which also decreases the frequency of spells in the streamflow record (Figure 3-1(C)).

Each of these changes to the duration and frequency of spells will also affect the statistical distribution of spells. For instance, the addition of a new spell event (case B in Figure 3-1) is likely to be a short duration event, which will increase the spell frequency and sample size but decrease the median spell duration. Alternatively, the merging of two spells into one event (case C in Figure 3-1) will create a long duration event, decreasing the spell frequency and sample size but increasing the duration of the 10<sup>th</sup> and 20<sup>th</sup> percentile spell durations. Hence it can be seen that different processes can alter the way that low flow spell statistics are interpreted. The dominant processes will determine how these changes appear in a statistical analysis of low flow spells.

■ **Figure 3-1 Types of low flow spells**



### 3.4 Results

Spells were analysed for two flow thresholds of 4 ML/d and 7 ML/d over the period 1965 to 2000. The spells below 4 ML/d are included in those below 7 ML/d. The characteristics of these spells are discussed below and the output data associated with these spells are provided in Appendix A.

As development increases in the catchment, the total number of days below each flow threshold increases. This is shown in Table 3-1.

■ **Table 3-1 Number of days below each flow threshold**

Flow Threshold (ML/d)	Natural conditions	Current conditions	Full development conditions
4	234	669	965
7	1422	2277	2528

The maximum spell duration also increases with increasing development. This is shown in Table 3-2. Increases in the maximum spell duration mean that the worst periods of drought are being extended.

■ **Table 3-2 Maximum spell duration**

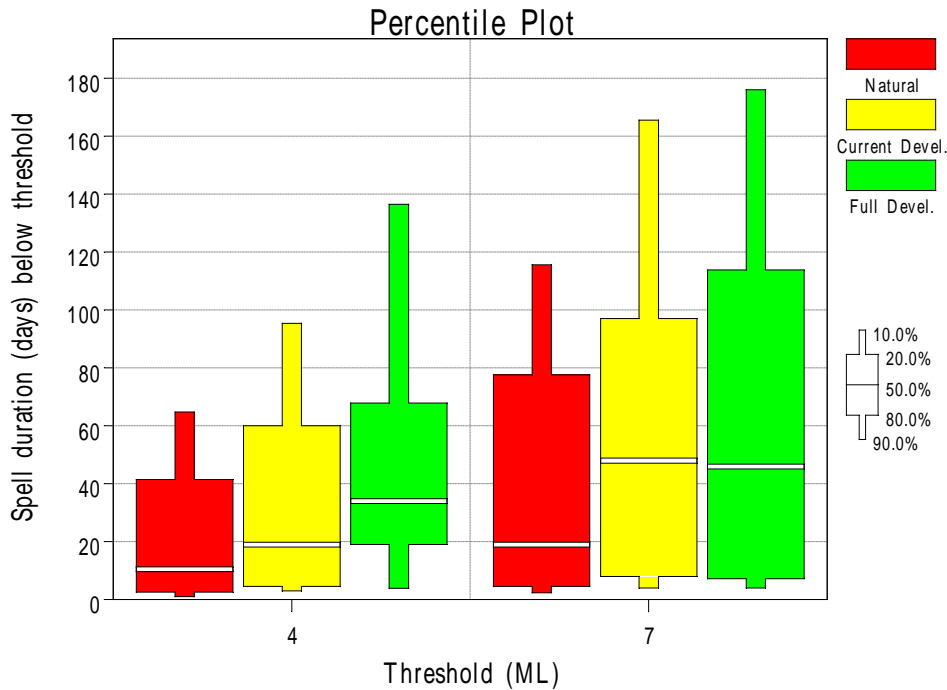
Flow Threshold (ML/d)	Natural conditions	Current conditions	Full development conditions
4	81	151	159
7	188	206	209

Figure 3-2 shows the duration of spells at given exceedance percentiles. It can be seen from this figure, for instance, that under natural conditions, the spell duration exceeded 10% of the time for flows less than 4 ML/d increases from approximately 65 days under natural conditions to 95 days under current conditions and 136 days under full development conditions. It is difficult to obtain a clear picture of the effect of development on other spell percentiles because of the different processes occurring, as described in Section 3.3.

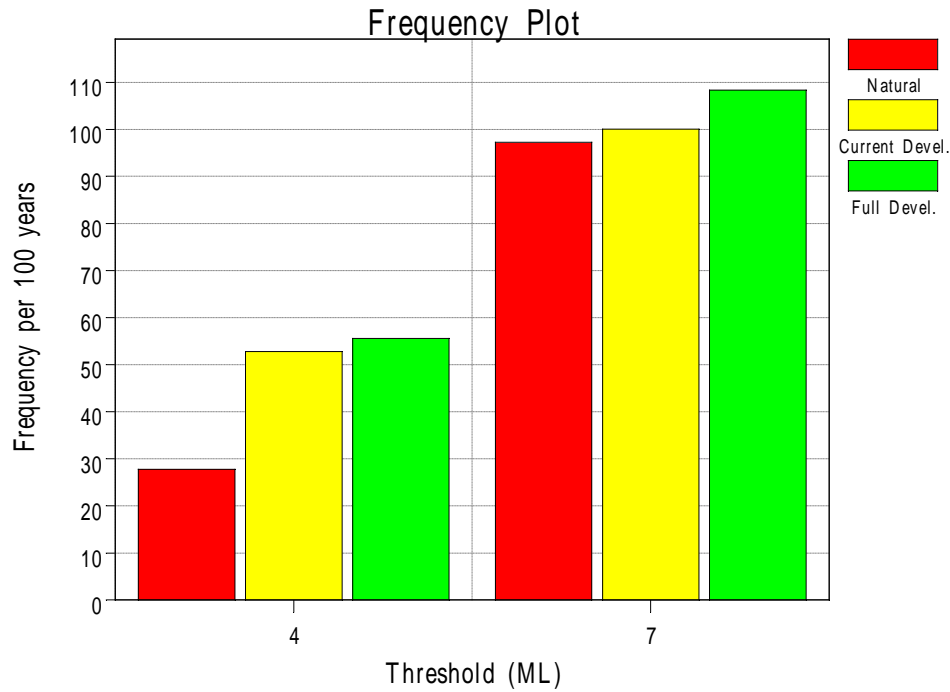
Figure 3-3 shows the spell frequency analysis. It can be seen from this figure that the frequency of spells typically increases as the level of development increases. This is a result of the formation of new spells below the given flow thresholds.

Figure 3-4 shows the start month of spells below the given flow thresholds. The width of the horizontal bars represents the number of spells starting in each month. Under current and full development conditions, there are more spells in each month and spells occur in more months of the year relative to natural conditions. This is consistent with the creation of spells that did not exist under natural conditions (Figure 3-1(B)).

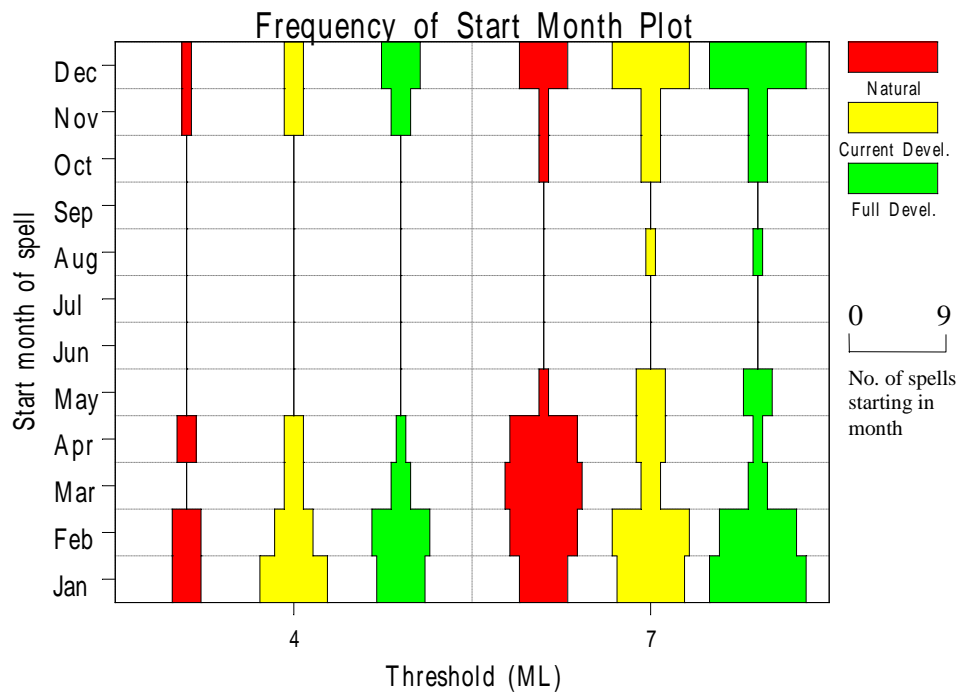
■ **Figure 3-2 Spell duration for flows below 4 ML/day and 7 ML/day (1965 – 2000)**



■ Figure 3-3 Number of spells per 100 years for flows below 4 ML/day and 7 ML/day (1965-2000)



■ Figure 3-4 Start month of spells below flows of 4 ML/day and 7 ML/day (1965-2000)



### 3.5 Summary of Results

In summary, an increase in water diversion from Hoddles Creek has:

- Increased the frequency of low flow spells.
- Increased the duration of existing low flow spells.
- Increased the number of months of the year in which low flow spells commence.

These effects are likely to increase if there is a full uptake of licensed diversions in the catchment.

## 4. References

Sinclair Knight Merz (2000a) *Stream Flow Management Plan for Hoddles Creek – Estimation of Streamflow and Demand Data and Development of REALM Model*. Prepared for Melbourne Water Corporation.

Sinclair Knight Merz (2000b) *The Impact of Farm Dams on Hoddles Creek and Diamond Creek Catchments*. Prepared for Melbourne Water Corporation.

## Appendix A Spell Analysis Output Data

Input file : C:\GETSPELL\NCFflows.fdy  
 Input data type : Daily time series data  
 Input file format : (i8,F12.0,F12.0,F12.0)  
 Number header lines : 0  
 Number of scenarios : 3  
 Number data read in : 13149 13149 13149  
 Number data missing : 0 0 0  
 Missing data criterion: All data < 0.00  
 First record read : 19650101 14.2700 11.5200 10.7100  
 Last record read : 20001231 10.5200 9.6500 7.5000  
 This file created on : 12:35 2 November 2001  
 GetSpells program : Version 1.4

Characteristic : Spell duration below thresholds  
 Time interval of data is: days  
 Volume unit of data is : ML  
 Months included are : Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Threshold number :	1	2
Magnitude :	4.00	7.00
Number of spells :		
Scenario 1	10	35
Scenario 2	19	36
Scenario 3	20	39

Scenario 1 (Natural); all spells

Statistic	Threshld 1	Threshld 2
Minimum :	1.0	1.0
Maximum :	81.0	188.0
Average :	23.4	40.6
Std Dev :	28.1	52.1
Cv :	1.200	1.281
Skewness :	1.346	1.658
AutoCorr :	-0.123	0.197
Number :	10	35
Missing :	0	0

Scenario 2 (Current Devel.); all spells

Statistic	Threshld 1	Threshld 2
Minimum :	1.0	3.0
Maximum :	151.0	206.0
Average :	35.2	63.3
Std Dev :	41.9	60.3
Cv :	1.189	0.954
Skewness :	1.697	0.985

AutoCorr : 0.065 0.041  
 Number : 19 36  
 Missing : 0 0

Scenario 3 (Full Devel.); all spells

Statistic	Threshld 1	Threshld 2
Minimum :	2.0	1.0
Maximum :	159.0	209.0
Average :	48.3	64.8
Std Dev :	47.7	63.6
Cv :	0.989	0.981
Skewness :	1.579	0.916
AutoCorr :	-0.022	0.138
Number :	20	39
Missing :	0	0

Scenario 1 (Natural); all spells

Percentile	Threshld 1	Threshld 2
0.00	81.0	188.0
5.00	72.9	160.6
10.00	64.8	115.6
15.00	53.5	90.7
20.00	41.4	77.6
25.00	32.2	50.5
30.00	25.5	37.8
35.00	20.0	34.3
40.00	16.8	20.4
45.00	13.7	19.7
50.00	10.5	19.0
55.00	7.4	16.6
60.00	7.0	13.6
65.00	7.0	7.9
70.00	5.8	7.0
75.00	4.0	5.5
80.00	2.6	4.6
85.00	1.7	3.0
90.00	1.0	2.4
95.00	1.0	2.0
100.00	1.0	1.0

Scenario 2 (Current Devel.); all spells

Percentile	Threshld 1	Threshld 2
0.00	151.0	206.0
5.00	116.8	182.0
10.00	95.4	165.5
15.00	69.3	134.8
20.00	60.0	97.0
25.00	46.0	86.8

30.00	31.2	81.0
35.00	28.2	73.5
40.00	23.0	67.0
45.00	19.0	56.5
50.00	19.0	48.0
55.00	19.0	40.3
60.00	15.8	33.0
65.00	12.9	22.0
70.00	9.6	17.0
75.00	6.5	10.5
80.00	4.6	8.0
85.00	3.7	5.3
90.00	3.0	4.0
95.00	2.8	3.0
100.00	1.0	3.0

Scenario 3 (Full Devel.); all spells

Percentile	Threshld 1	Threshld 2
0.00	159.0	209.0
5.00	158.1	182.1
10.00	136.4	176.0
15.00	80.5	149.1
20.00	67.8	113.8
25.00	51.3	98.0
30.00	41.8	81.0
35.00	38.0	72.4
40.00	36.4	63.8
45.00	34.9	60.0
50.00	34.0	46.0
55.00	31.8	38.5
60.00	28.6	30.2
65.00	27.3	20.6
70.00	24.8	12.2
75.00	21.5	8.0
80.00	19.0	7.2
85.00	13.4	5.4
90.00	3.9	4.0
95.00	3.0	2.9
100.00	2.0	1.0

Frequency per 100 Years of spells between duration limits:

Threshold	Duration	Scenario1	Scenario2	Scenario3
4.00	All	27.8	52.8	55.6
7.00	All	97.2	100.0	108.3

Frequency of start month of spells between duration limits:

Threshold	Duration	Month	Scenario1	Scenario2	Scenario3
4.00	All	Jan	3	7	5

	Feb	3	4	6
	Mar	0	2	2
	Apr	2	2	1
	May	0	0	0
	Jun	0	0	0
	Jul	0	0	0
	Aug	0	0	0
	Sep	0	0	0
	Oct	0	0	0
	Nov	1	2	2
	Dec	1	2	4
7.00	All Jan	5	7	10
	Feb	7	8	8
	Mar	8	2	2
	Apr	7	3	1
	May	1	3	3
	Jun	0	0	0
	Jul	0	0	0
	Aug	0	1	1
	Sep	0	0	0
	Oct	1	2	2
	Nov	1	2	2
	Dec	5	8	10

Scenario 1 (Natural)

Threshold	Spell	Start_Date	End_Date	duration
4.0	1	19680114	19680421	63
	2	19800218	19800422	36
	3	19810117	19810117	1
	4	19810203	19810301	21
	5	19820215	19820306	7
	6	19821125	19821204	7
	7	19821225	19830423	81
	8	19980409	19980411	3
	9	20000121	20000121	1
	10	20000401	20000429	14
7.0	1	19660105	19660315	58
	2	19660403	19660421	13
	3	19670208	19670321	21
	4	19670407	19670729	88
	5	19671022	19680428	176
	6	19690123	19690222	19
	7	19690408	19690415	5
	8	19700208	19700318	18
	9	19740222	19740403	37
	10	19790301	19790301	1
	11	19790321	19790323	3
	12	19791206	19800529	154
	13	19801210	19810309	75
	14	19810325	19810506	38

15	19811227	19820425	100
16	19821103	19830528	188
17	19840112	19840324	43
18	19840408	19840415	8
19	19880225	19880310	14
20	19880329	19880505	34
21	19890129	19890130	2
22	19890219	19890320	20
23	19890404	19890405	2
24	19890424	19890430	7
25	19900308	19900327	16
26	19910307	19910309	3
27	19910407	19910508	20
28	19950305	19950307	3
29	19971222	19980606	126
30	19990201	19990206	6
31	19990313	19990319	5
32	19990506	19990507	2
33	19991201	19991224	19
34	20000112	20000126	7
35	20000211	20000526	91

Scenario 2 (Current Devel.)

Threshold	Spell	Start_Date	End_Date	duration
4.0	1	19660106	19660213	30
	2	19670208	19670224	8
	3	19671101	19671211	32
	4	19671226	19680428	113
	5	19700209	19700228	3
	6	19740301	19740324	19
	7	19791208	19800109	19
	8	19800129	19800510	91
	9	19810101	19810308	60
	10	19810411	19810427	12
	11	19820101	19820322	60
	12	19821105	19830430	151
	13	19840211	19840227	15
	14	19980104	19980104	1
	15	19980121	19980123	3
	16	19980312	19980519	24
	17	20000121	20000126	4
	18	20000219	20000223	5
	19	20000401	20000430	19
7.0	1	19650201	19650306	33
	2	19651222	19660316	83
	3	19660402	19660421	18
	4	19670101	19670322	74
	5	19670406	19670730	97
	6	19671016	19680429	191
	7	19681215	19690223	56

8	19690407	19690415	8
9	19700201	19700318	41
10	19721204	19730130	58
11	19740124	19740403	67
12	19750308	19750310	3
13	19760305	19760316	11
14	19770212	19770217	6
15	19780227	19780312	3
16	19790116	19790331	55
17	19791127	19800529	179
18	19801201	19810506	137
19	19811201	19820427	128
20	19820828	19820901	4
21	19821013	19830529	206
22	19831228	19840416	89
23	19840518	19840522	5
24	19850212	19850331	25
25	19880113	19880505	86
26	19890126	19890430	72
27	19900115	19900131	16
28	19900220	19900410	38
29	19910202	19910508	79
30	19910528	19910531	4
31	19950225	19950327	21
32	19971201	19980606	174
33	19981212	19981225	3
34	19990115	19990320	41
35	19990503	19990512	9
36	19991103	20000526	157

Scenario 3 (Full Devel.)

Threshold	Spell	Start_Date	End_Date	duration
4.0	1	19660102	19660213	40
	2	19670201	19670228	28
	3	19670316	19670317	2
	4	19671101	19680428	158
	5	19690109	19690221	34
	6	19700201	19700228	26
	7	19721221	19730130	34
	8	19740219	19740331	37
	9	19791201	19800510	134
	10	19801212	19810309	71
	11	19810410	19810427	15
	12	19820101	19820322	67
	13	19821103	19830430	159
	14	19840202	19840310	29
	15	19890202	19890228	22
	16	19980101	19980124	20
	17	19980309	19980519	36
	18	19991207	19991209	3

	19	20000121	20000126	4
	20	20000211	20000430	46
7.0	1	19650201	19650312	38
	2	19650330	19650331	2
	3	19651222	19660421	103
	4	19670101	19670730	181
	5	19671016	19680429	192
	6	19681214	19690309	63
	7	19690407	19690415	8
	8	19700201	19700319	46
	9	19710307	19710309	3
	10	19721201	19730130	61
	11	19740120	19740403	73
	12	19750219	19750323	22
	13	19760201	19760320	30
	14	19770201	19770224	20
	15	19771207	19771225	17
	16	19780111	19780129	8
	17	19780225	19780316	8
	18	19790112	19790331	64
	19	19791126	19800529	180
	20	19801201	19810506	141
	21	19811201	19820427	130
	22	19820828	19820901	4
	23	19821012	19830529	209
	24	19831223	19840416	97
	25	19840517	19840522	6
	26	19850127	19850413	51
	27	19880112	19880505	99
	28	19890125	19890430	75
	29	19900103	19900410	71
	30	19910201	19910508	85
	31	19910528	19910531	4
	32	19950104	19950104	1
	33	19950219	19950330	31
	34	19971201	19980606	175
	35	19981211	19981225	6
	36	19990115	19990320	43
	37	19990503	19990512	9
	38	19991103	20000526	168
	39	20001215	20001221	4