



## MEMORANDUM

**TO:** Lisa Mead and Nick Eldred (Meridian Energy Limited)

**FROM:** Ned Norton

**SUBJECT:** Results from water quality monitoring in the lower Waitaki catchment over the 2006/07 summer. Provision of results for interested parties for their information during the submission process

**DATE:** 17 May, 2007

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Attached are the results now available from weekly water quality monitoring of 14 sites in the lower Waitaki River catchment over the 2006/07 summer (6 December 2006 to 3 April 2007 inclusive).

Six sites are on the Lower Waitaki River mainstem. These sites were sampled via foot access to the nearest main braid edge at the sites shown on Figure 1. These are:

- Waitaki River @ Waitaki Dam
- Waitaki River @ Kurow Boat Ramp
- Waitaki River @ Priest Road
- Waitaki River @ Duntroon
- Waitaki River @ Stonewall
- Waitaki River @ SH Bridge

Eight sites are on tributaries of the lower Waitaki River. These were sampled at or near the point where the main road (either Kurow to Oamaru road or Kurow to Waimate road) crosses each tributary, as indicated on Figure A (the exception is Welcome Creek which was sampled as indicated on Figure A). These are:

- Awakino River
- Hakatamea River
- Kurow Creek
- Otiake River
- Otekaieke River
- Maerewhenua River
- Awamoko River
- Welcome Creek

Sites were sampled according to standard NIWA (National River Water Quality Network) NRWQN sampling protocols and analyses for physical and chemical water quality were performed by the NIWA Hamilton laboratory.

Samples were also taken for microbiological analyses (*E. coli* and *Campylobacter*). These analyses were performed by the ESR Christchurch laboratories and results and analyses compiled by Andrew Ball at ESR.

Plots are attached showing spatial patterns between sites for the nutrients DIN (dissolved inorganic nitrogen) (Figure i) and DRP (dissolved reactive phosphorus) (Figure ii). These are shown as box and whisker plots representing all sampling dates for each site. This allows an examination of the longitudinal pattern of DIN and DRP concentrations moving downstream in the Waitaki River mainstem. It also allows comparison of mainstem versus tributary nutrient concentrations.

Plots are also attached showing trends in each measured variable at each site through time. These trend plots are organized so that there is one page per site (Figures 1 to 14).

Statistical summary tables are attached for DIN and DRP data in Tables 1 and 2.

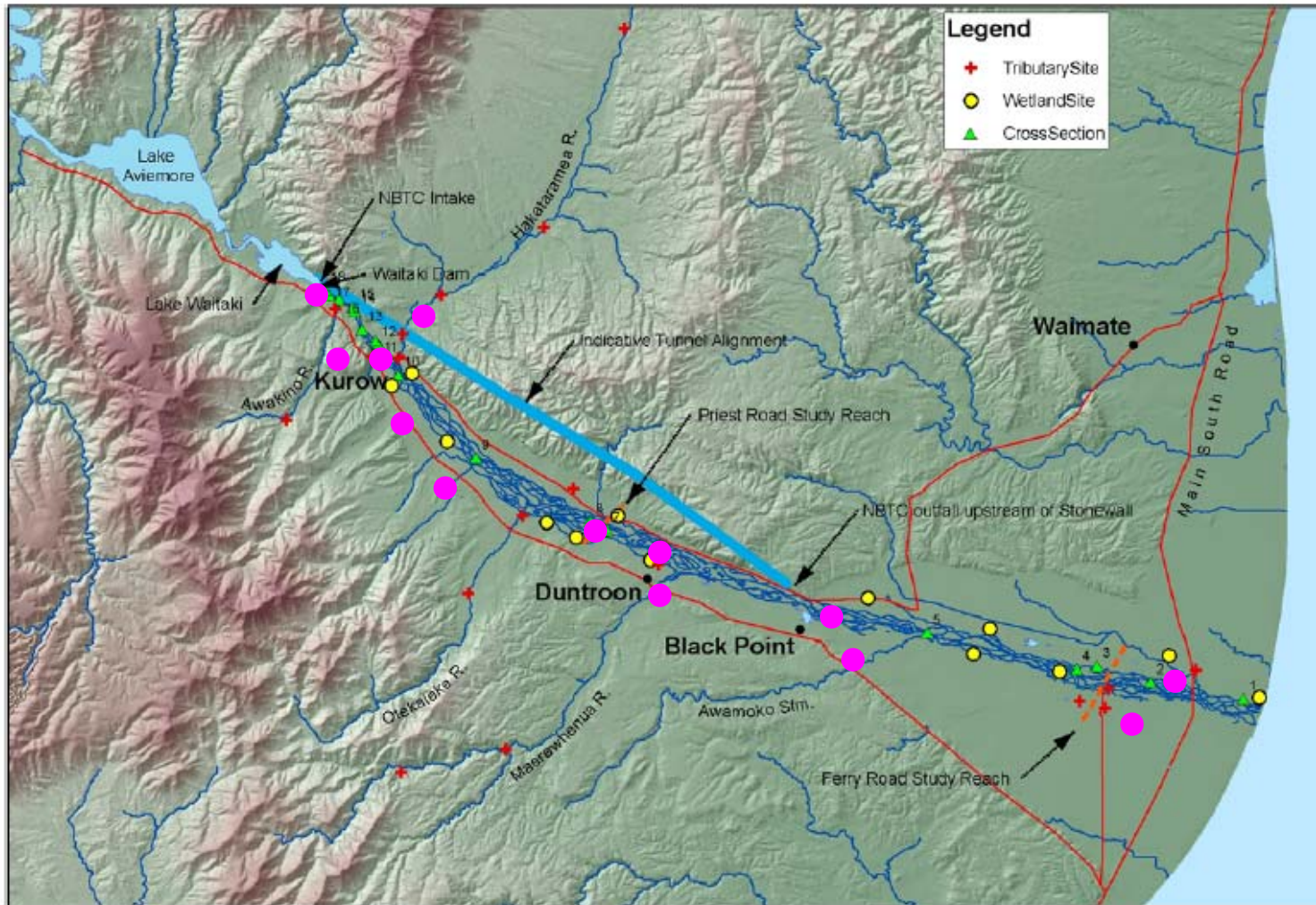
#### Analysis and implications for NBTC assessments of environmental effects

These results will be added to the water quality information provided in the NBTC report (North Bank Tunnel Concept - Water Consents: Physical and Chemical Water Quality (Larned and Norton, September 2006) and incorporated into hearing evidence in the coming weeks. In the meantime this memo is intended to provide the results and key graphical analyses for the benefit of interested parties preparing submissions on the NBTC consent application.

Key observations to draw from these summer 2006/07 weekly data are:

- Physical and chemical water quality in the Waitaki River is considerably poorer (with respect to concentrations of the nutrients nitrogen (DIN) and phosphorus (DRP)) at the State Highway Bridge than it is at sites between Waitaki Dam and Stonewall (see Figures i and ii). It appears that the majority of the nutrient load contributed to the mainstem river occurs downstream of Stonewall.
- Concentrations of nutrients are considerably higher in the tributaries than they are in the mainstem river between Waitaki Dam and Stonewall, confirming that the tributaries are significant contributors of nutrient contaminants to the mainstem river.
- However, the concentrations of nutrients in most of the tributaries are not as high as the mainstem Waitaki River at State Highway Bridge. The exceptions are Welcome Creek (which has higher DIN & DRP) and Awamoko Stream (which has higher DRP but similar DIN). Given the very large potentially diluting flows of the Waitaki mainstem (median flow around 370 m<sup>3</sup>/s) as compared to the relatively small flows of Welcome Creek and Awamoko Stream (a few m<sup>3</sup>/s at most), it follows that there must be significantly large other contributions of nutrients to the lower river that result in the concentrations observed at SH Bridge. These other contributions could include; any point sources such as effluent treatment systems not identified during this sampling programme, groundwater and surface overland flow from neighbouring land entering side-braid margins, other small tributaries and springs not measured in

this sampling programme, bird colonies on the mainstem, and stock grazing within the riverbed on the mainstem.



**Figure 1.1: Map of the lower Waitaki River, showing the indicative tunnel route, intake and outfall locations. Site locations are also shown for ecological and water quality sampling, topographic and water level survey cross-sections.**

Memo Figure A: New site locations sampled over the 2006/07 summer are shown as pink dots over the original sites in Figure 1.1 of the NBTC Physical and Chemical water quality report (September 2006).

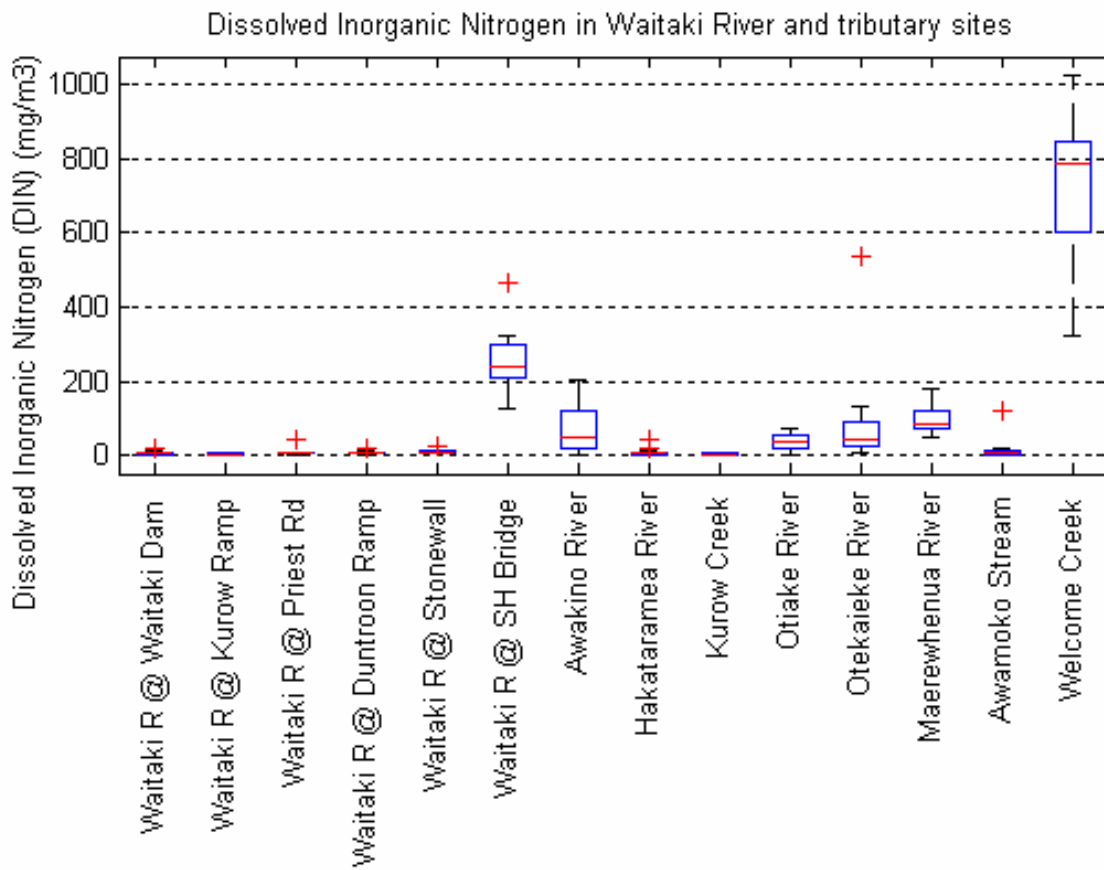


Figure (i): Box and whisker plot – DIN. The horizontal red line in each box is the median value ( $n = 16$ ); blue box upper and lower limits are upper and lower quartiles respectively; red crosses are 95 percentile outliers.

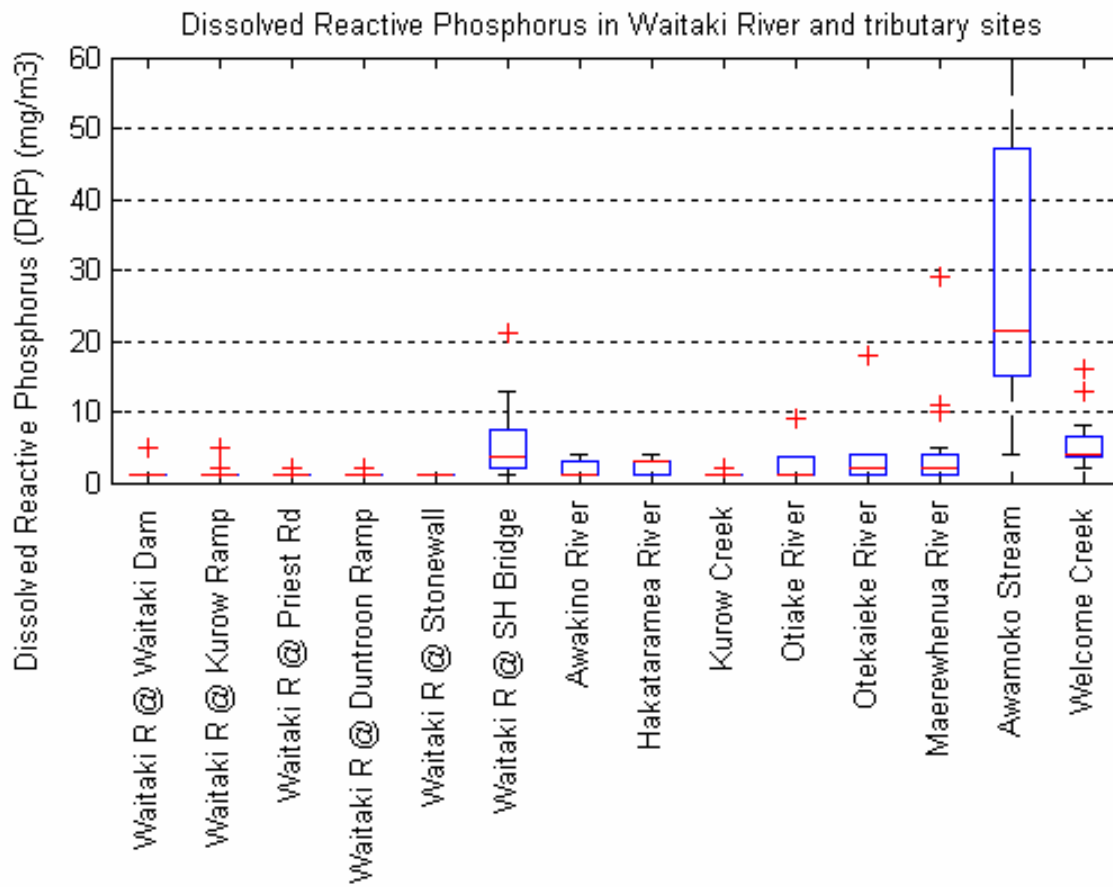


Figure (ii): Box and whisker plot – DRP. The horizontal red line in each box is the median value ( $n = 16$ ); blue box upper and lower limits are upper and lower quartiles respectively; red crosses are 95 percentile outliers.

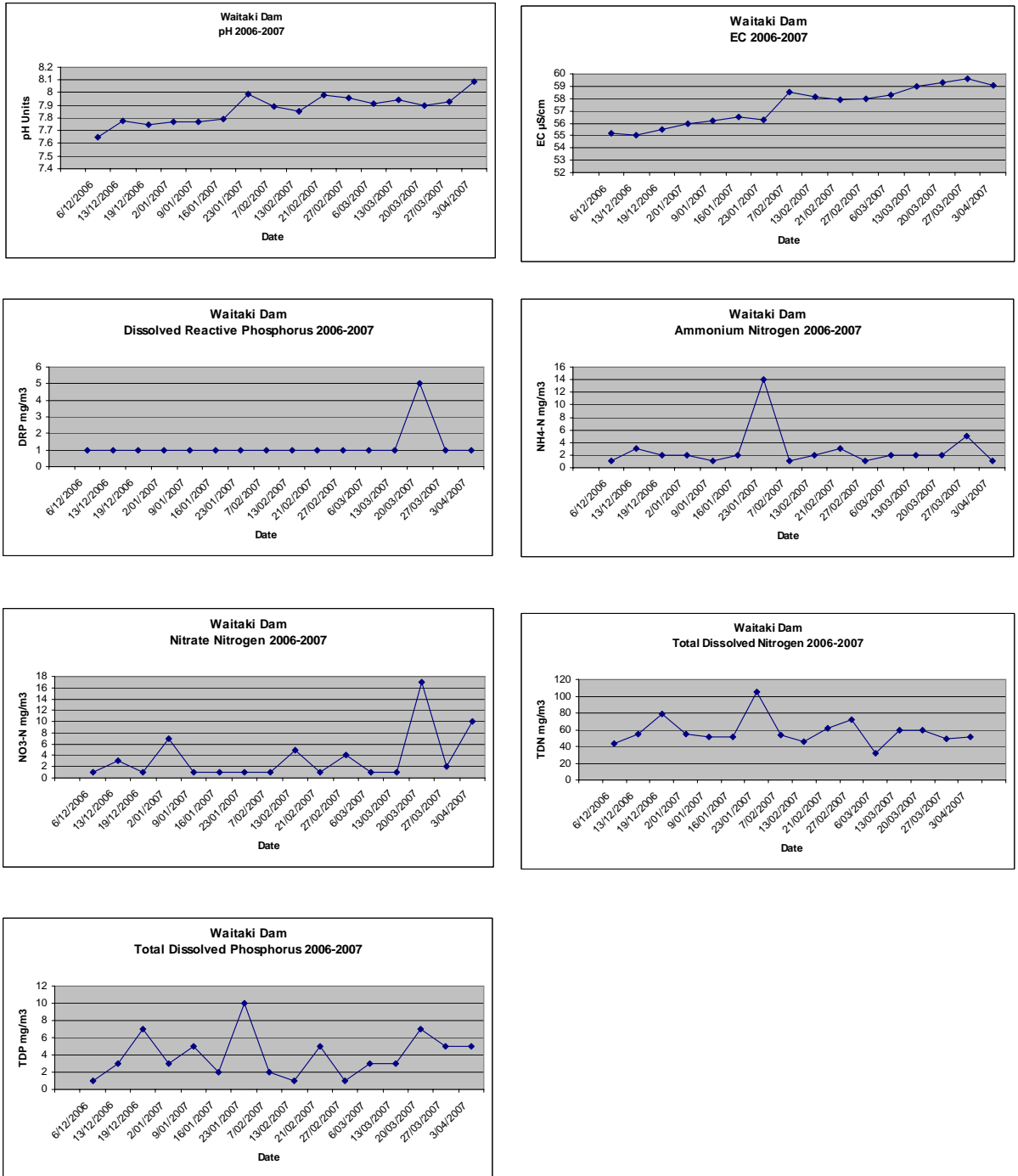


Figure 1: Trend through time for each water variable at Waitaki River @ Waitaki Dam

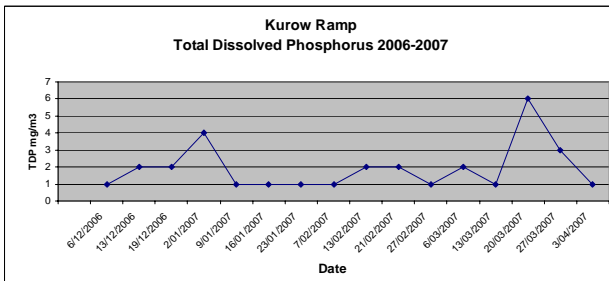
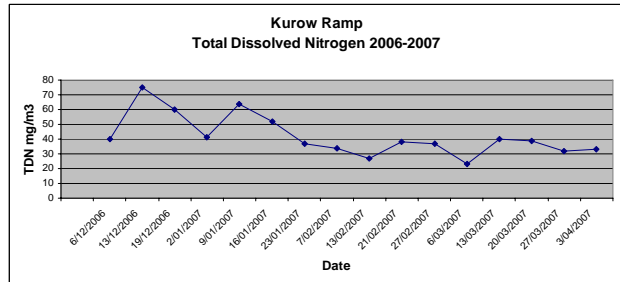
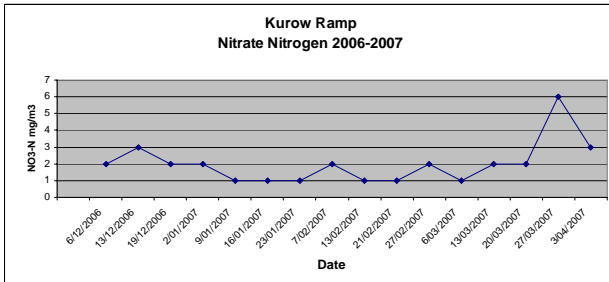
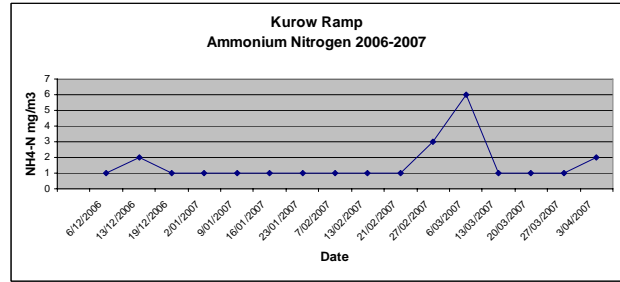
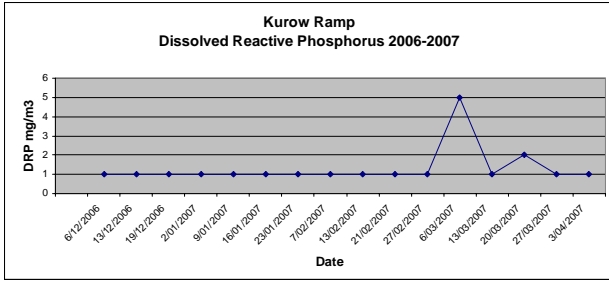
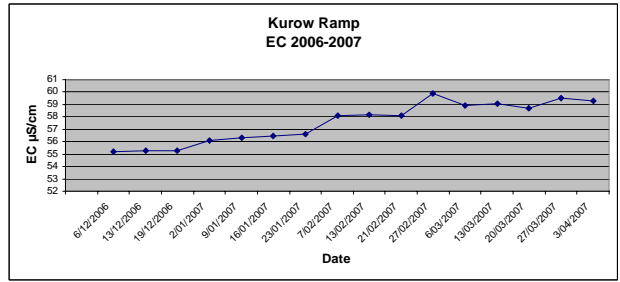
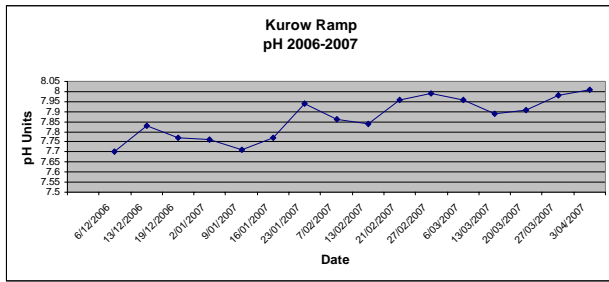


Figure 2: Trend through time for each water variable at Waitaki River @ Kurow Boat Ramp

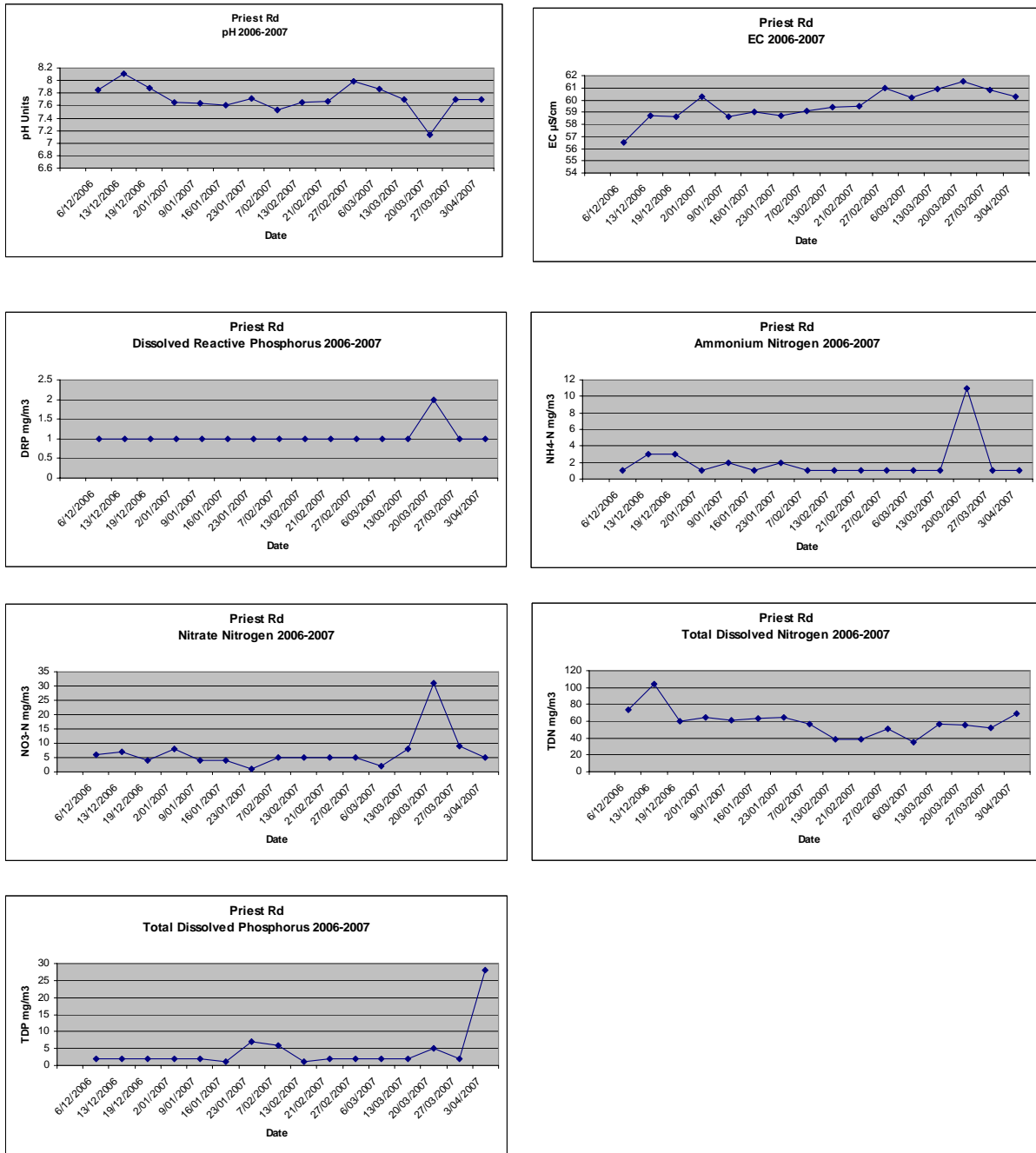


Figure 3: Trend through time for each water quality variable at Waitaki River @ Priest Road

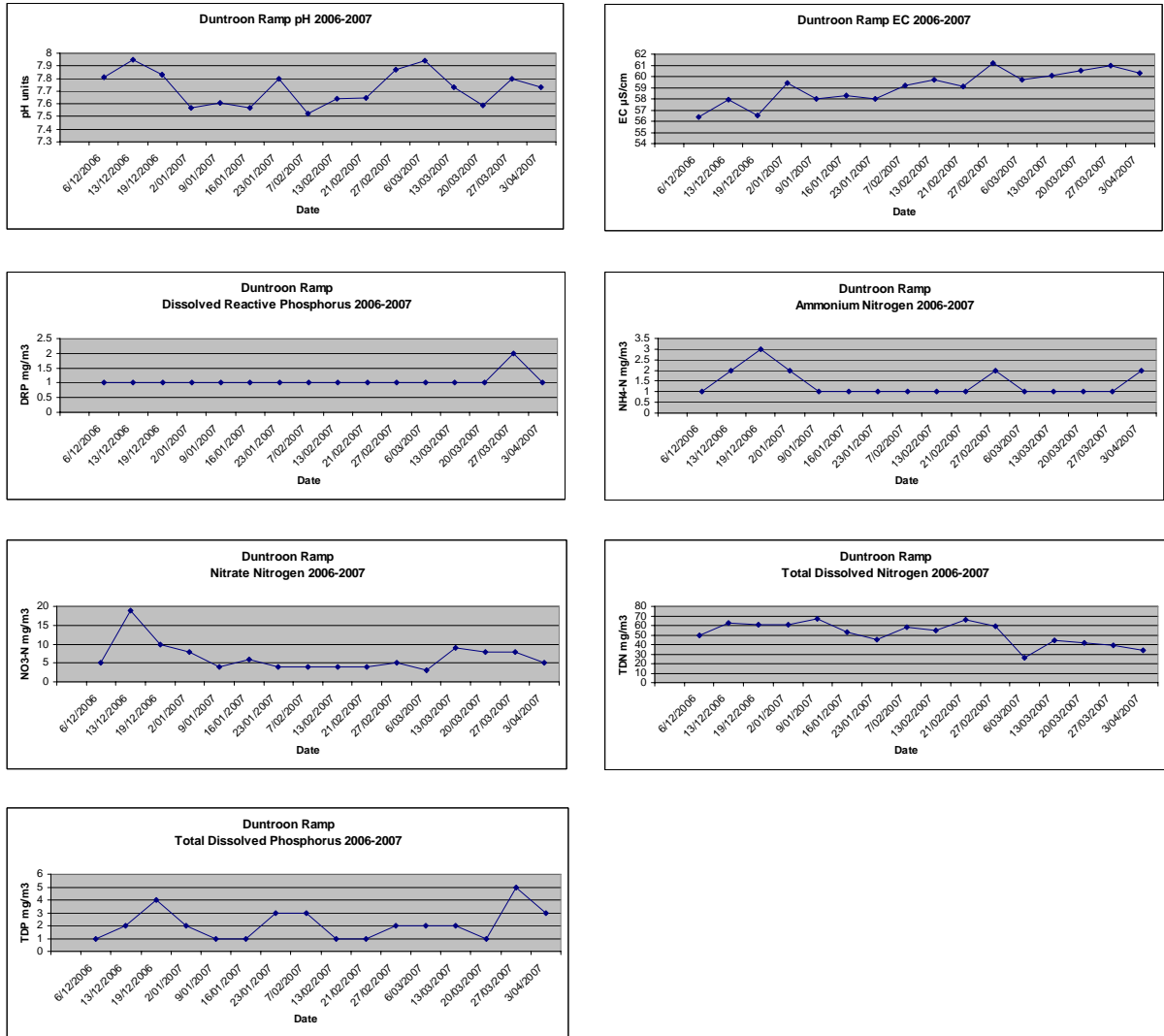


Figure 4: Trend through time for each water quality variable at Waitaki River @ Duntroon

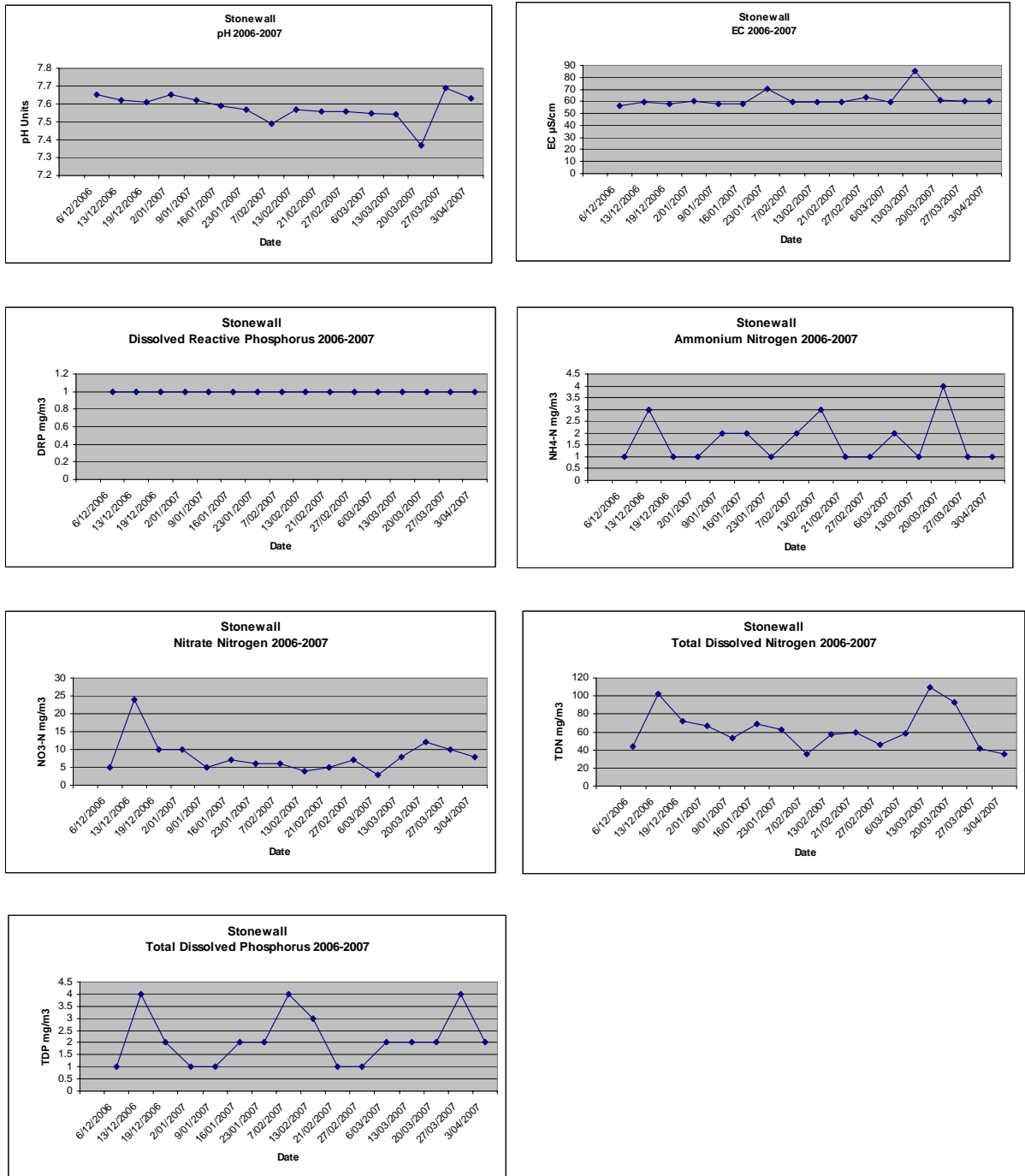


Figure 5: Trend through time for each water quality variable at Waitaki River @ Stonewall

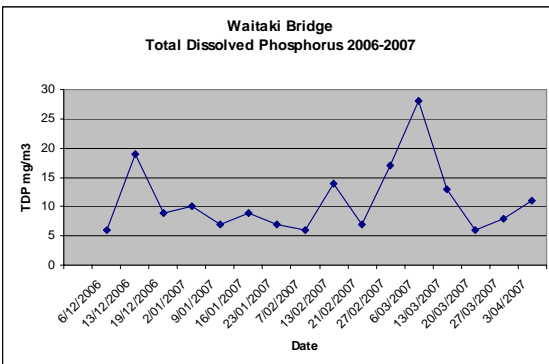
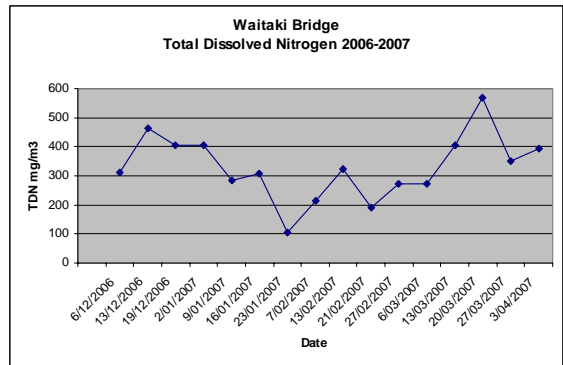
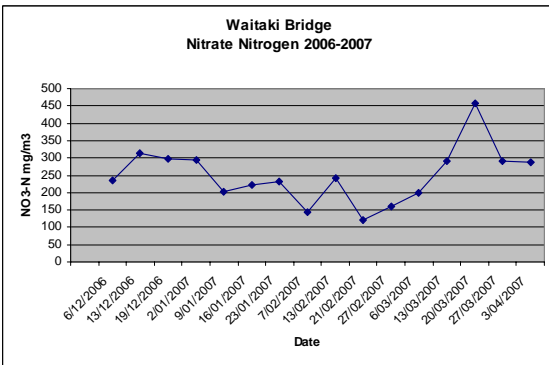
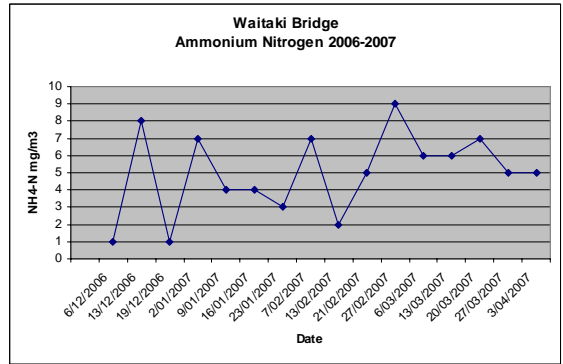
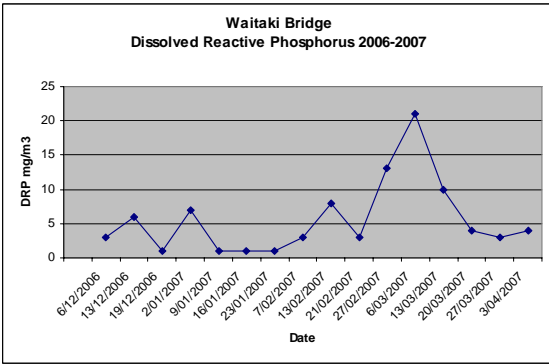
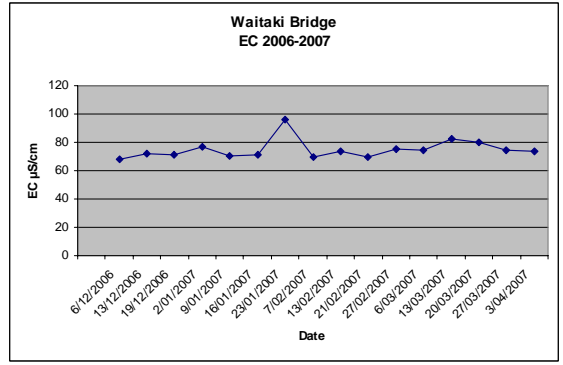
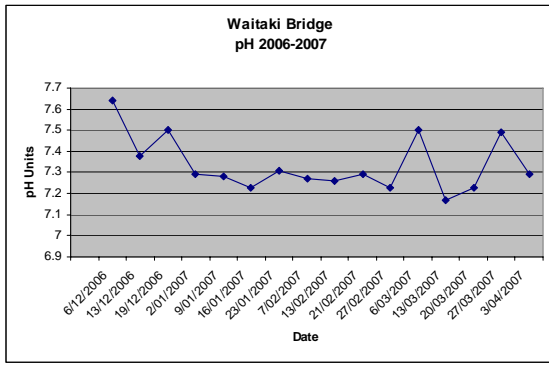


Figure 6: Trend through time for each water quality variable at Waitaki River @ SH Bridge

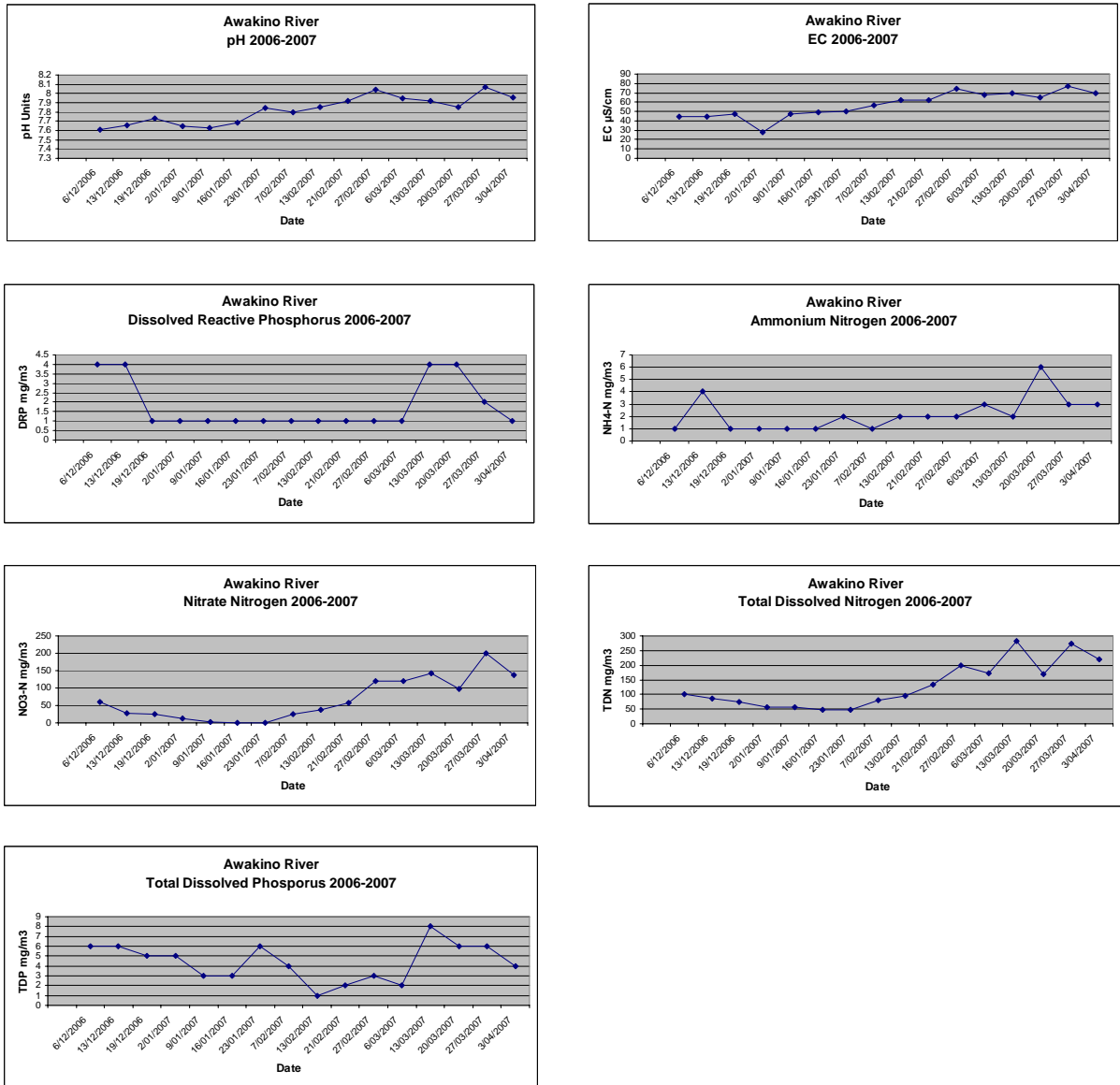


Figure 7: Trend through time for each water quality variable at Awakino River

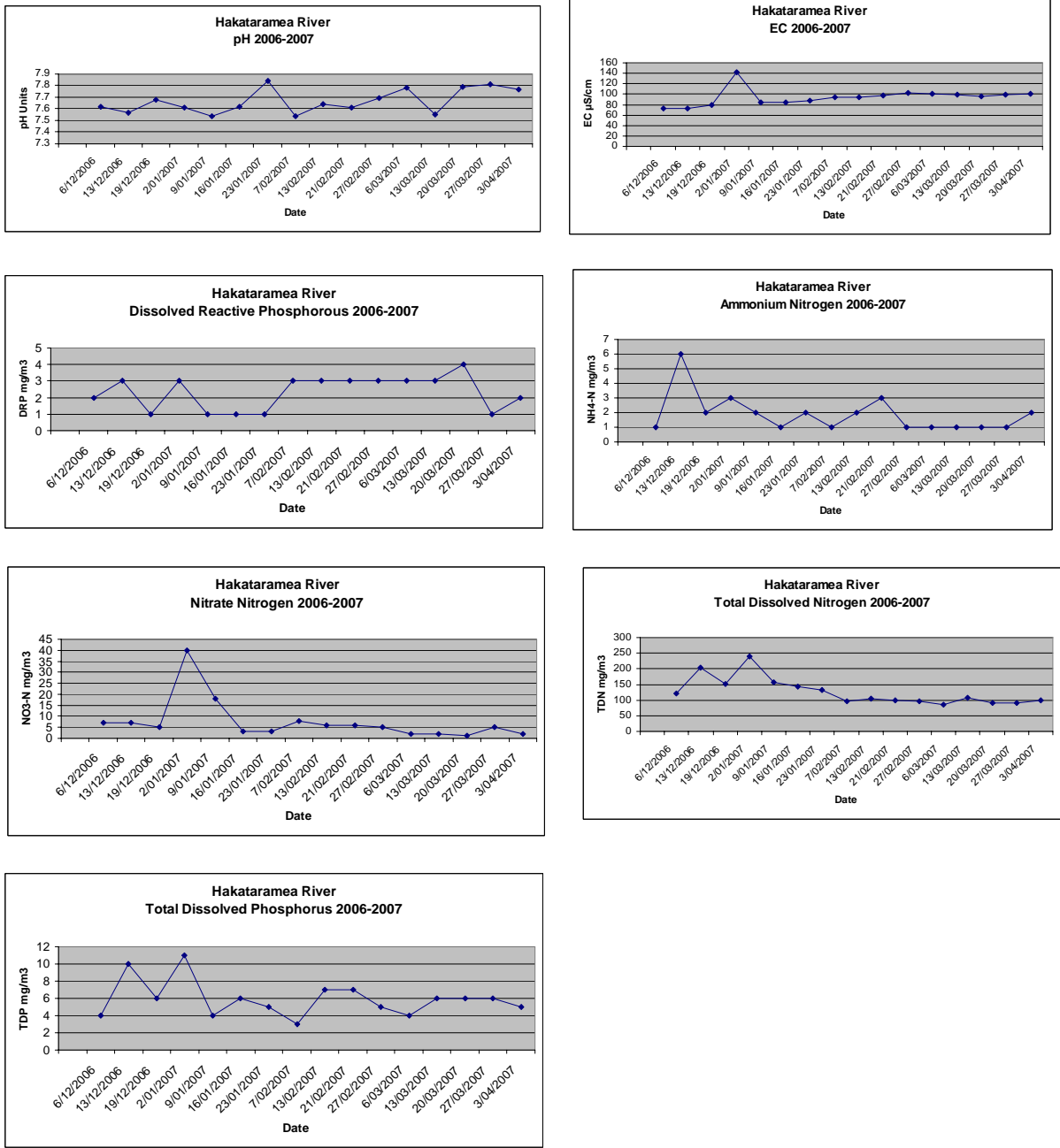


Figure 8: Trend through time for each water quality variable at Hakataramea River

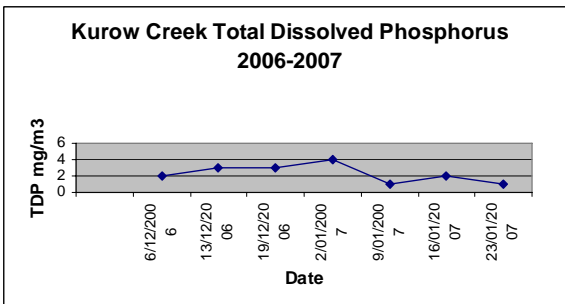
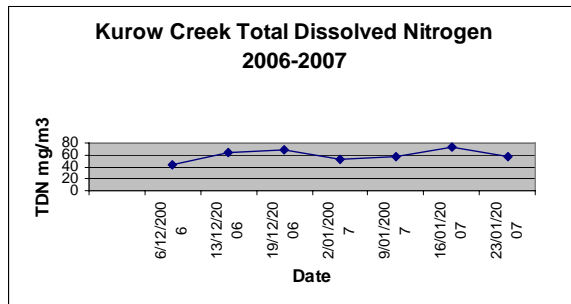
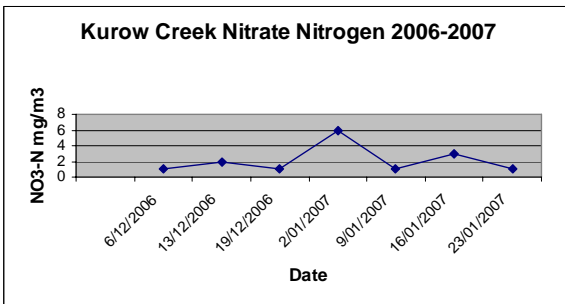
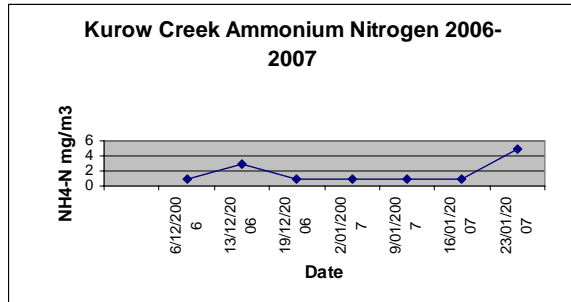
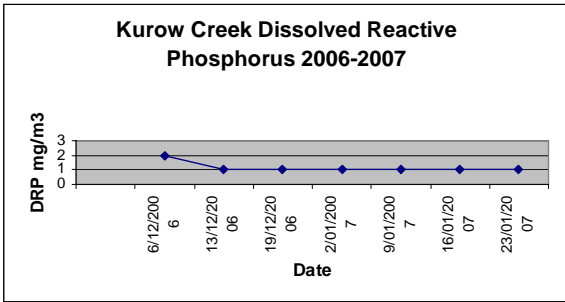
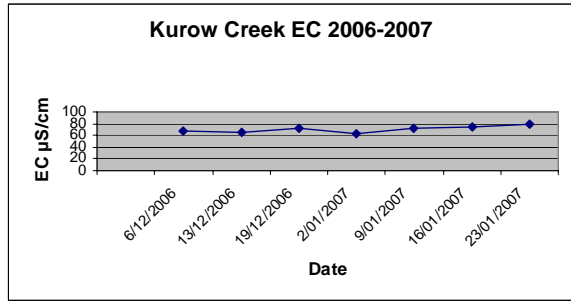
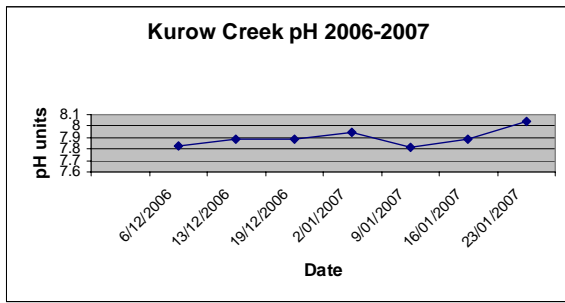


Figure 9: Trend through time for each water quality variable at Kurow Creek

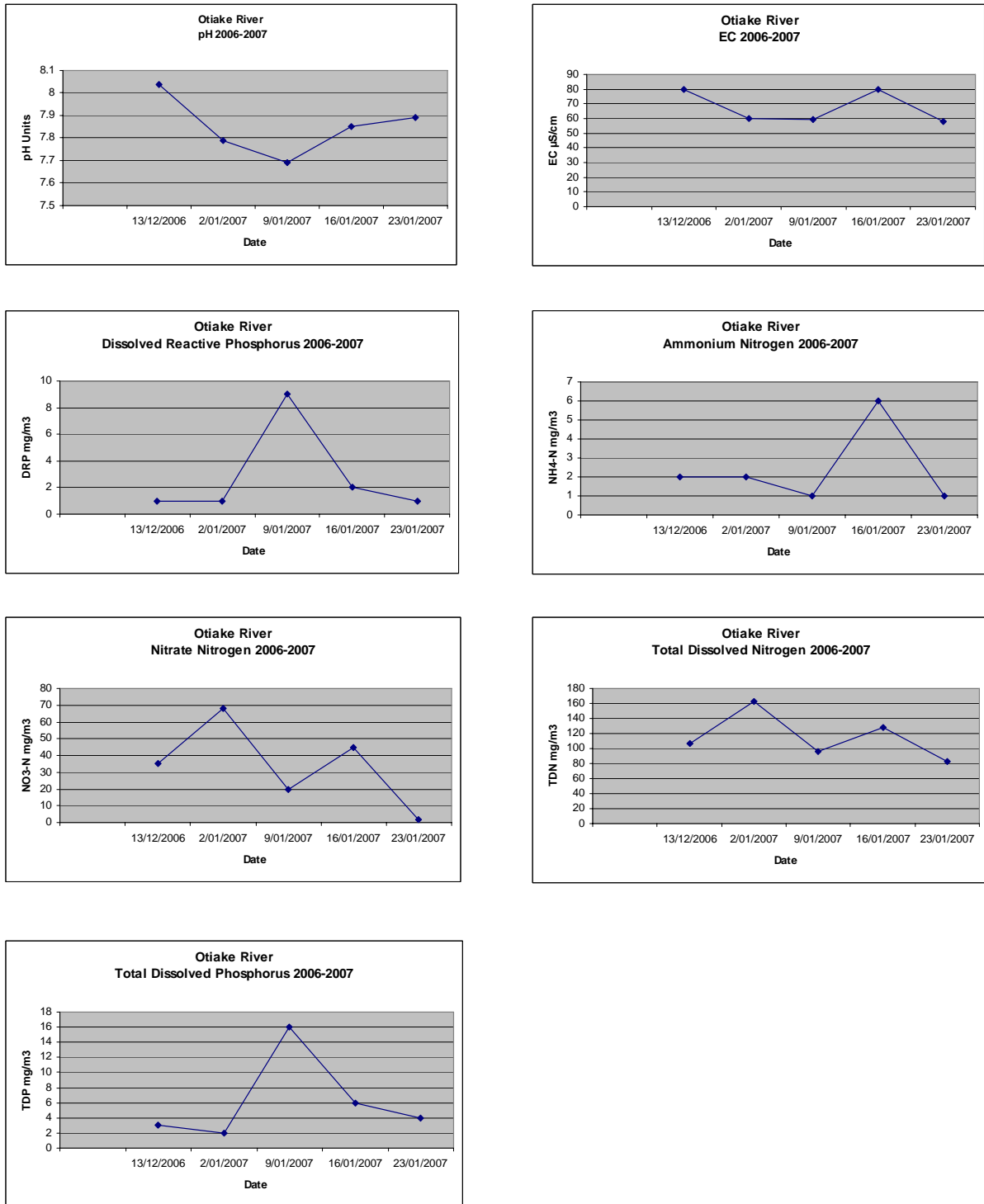


Figure 10: Trend through time for each water quality variable at Otiake River

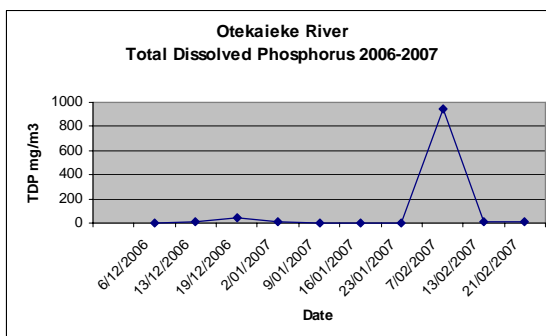
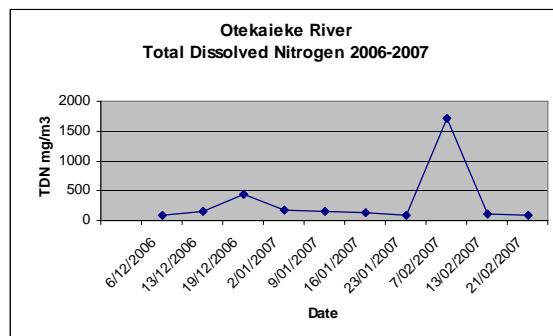
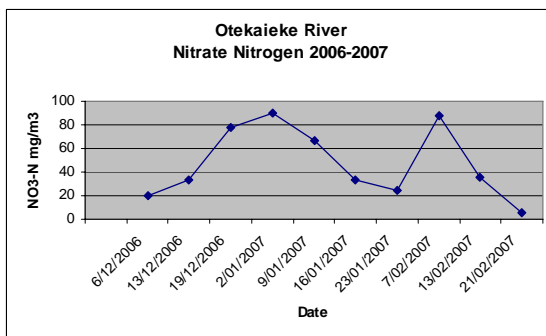
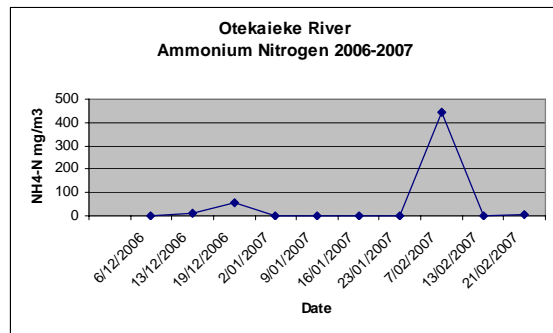
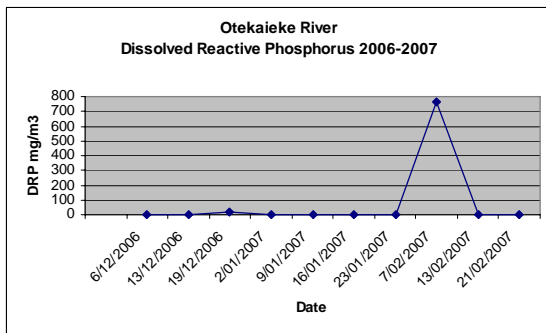
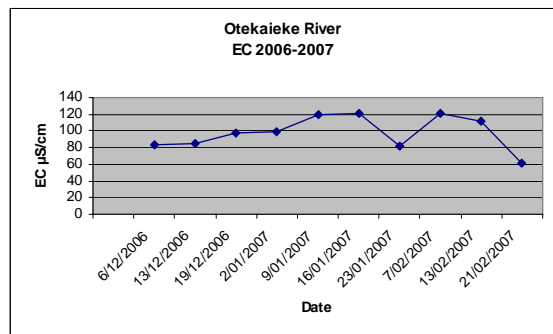
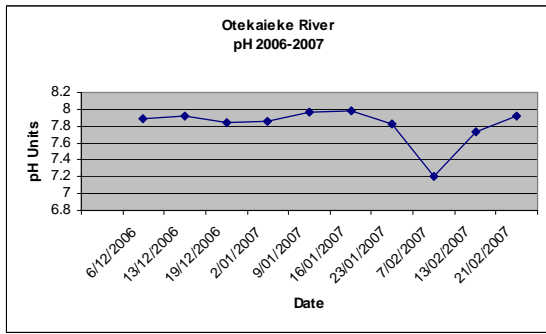


Figure 11: Trend through time for each water quality variable at Otekaieke River

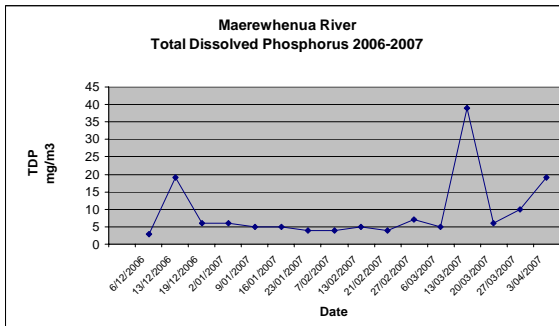
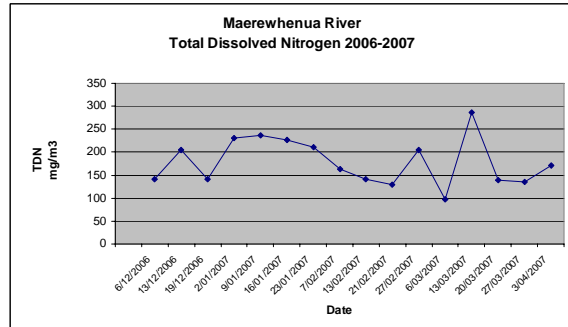
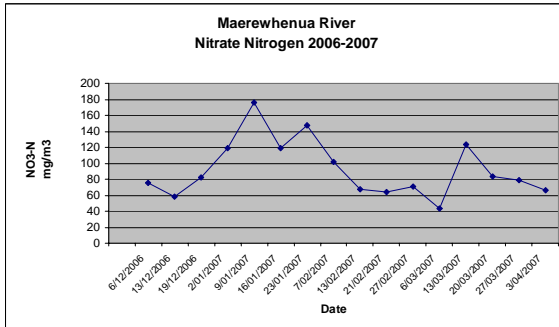
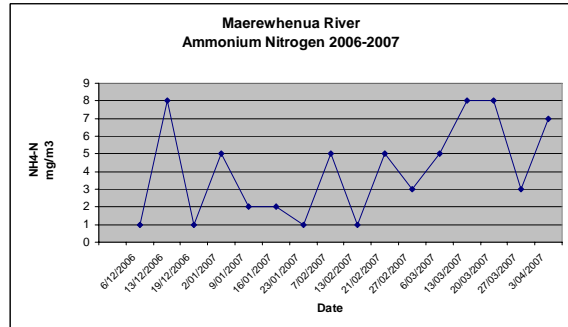
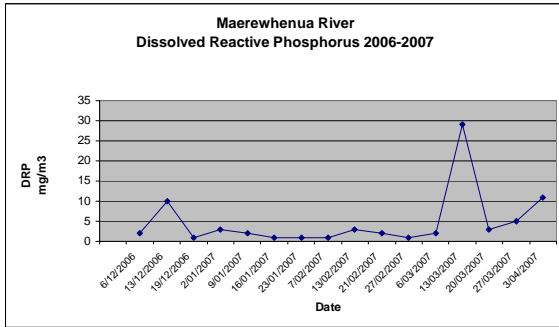
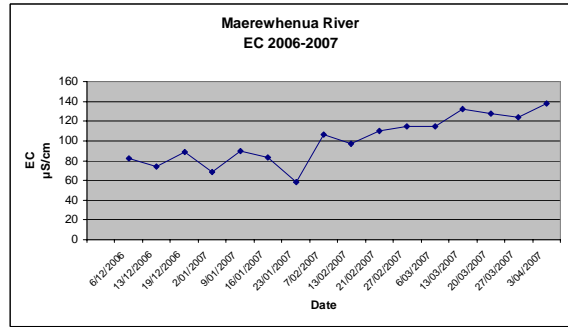
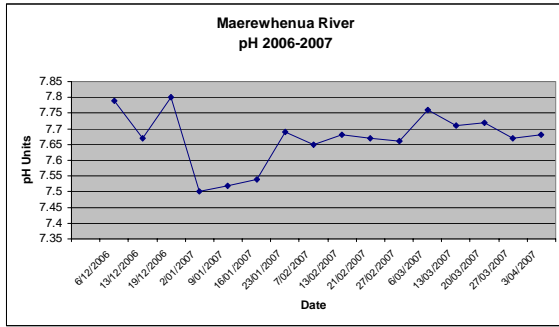


Figure 12: Trend through time for each water quality variable at Maerewhenua River

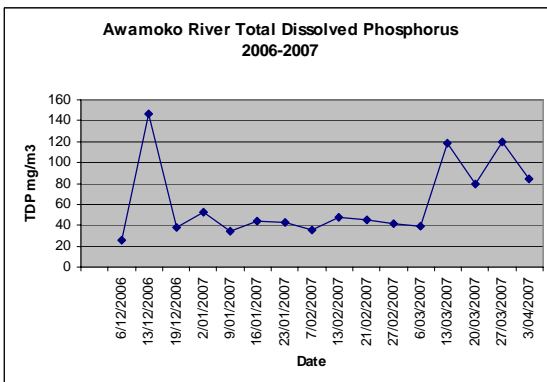
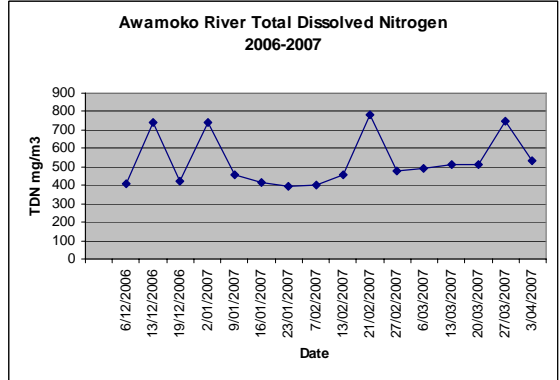
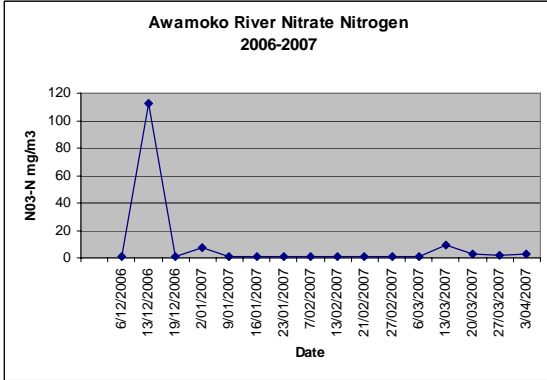
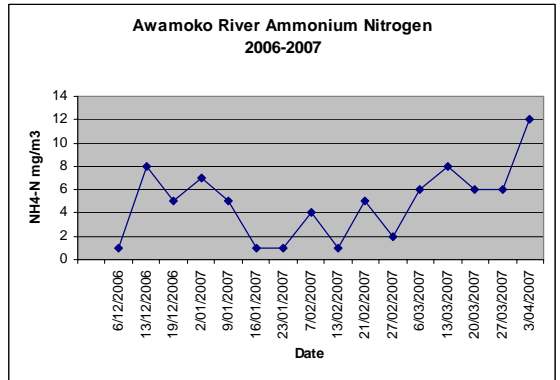
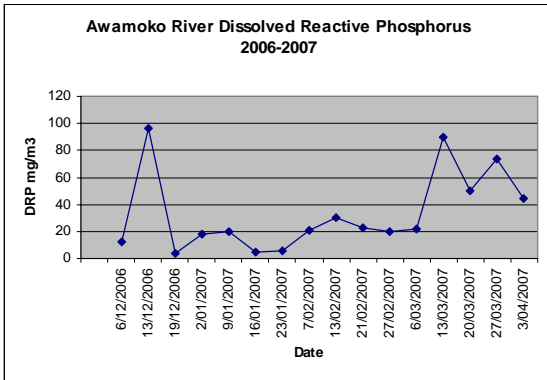
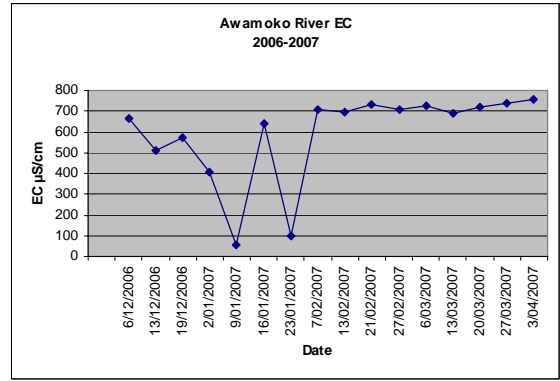
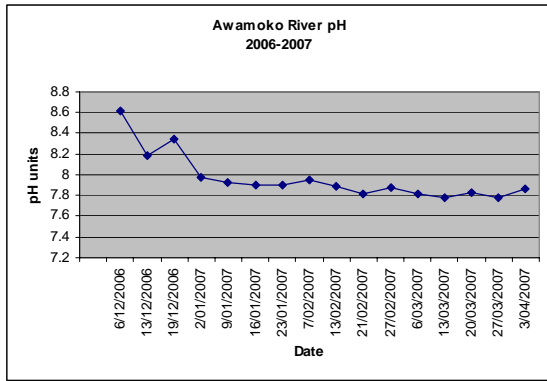


Figure 13: Trend through time for each water quality variable at Awamoko River

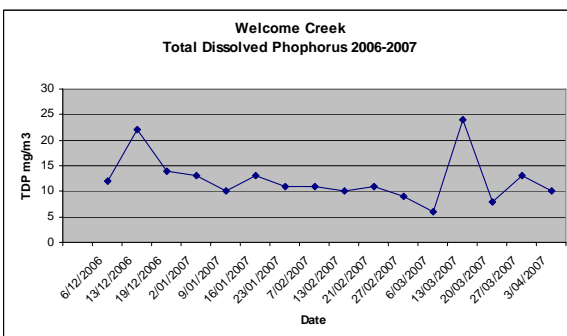
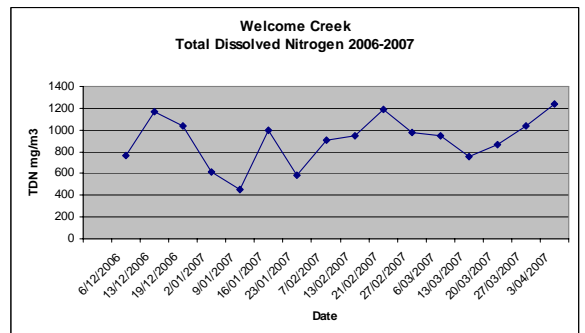
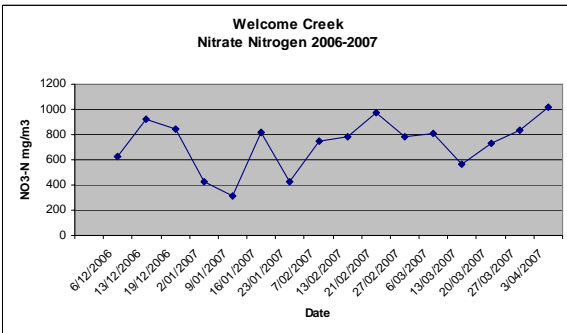
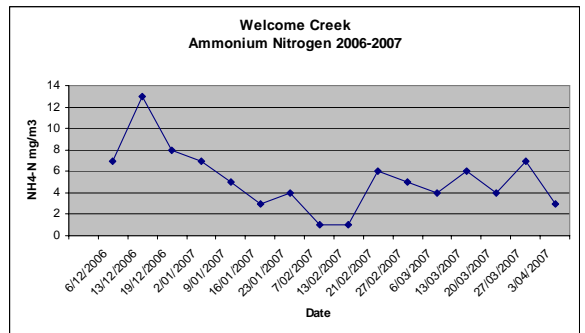
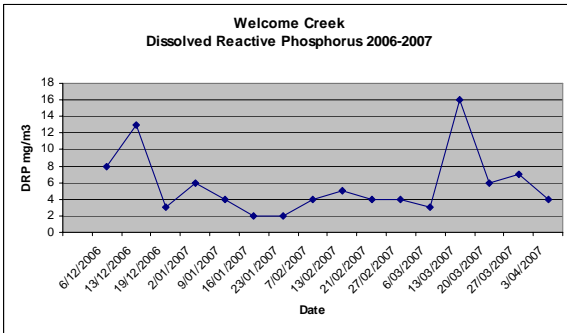
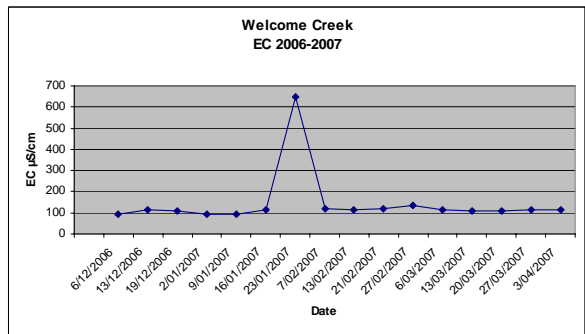
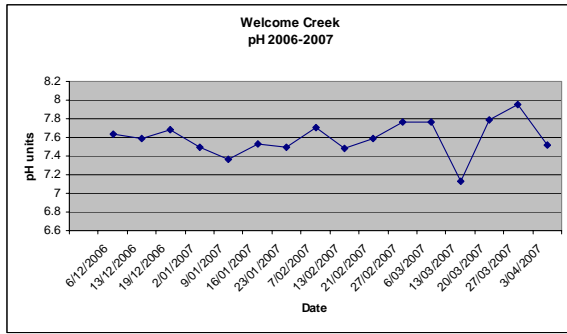


Figure 14: Trend through time for each water quality variable at Welcome Creek

Table 1: Statistical summaries for DIN data.

DIN mg/m3

Date Collected	Waitaki Dam DIN mg/m3	Kurow Ramp DIN mg/m3	Priest Rd DIN mg/m3	Dunroon Rd DIN mg/m3	Stonewall DIN mg/m3	Waitaki Bridge DIN mg/m3	Awakino River DIN mg/m3	Hakataramea DIN mg/m3	Kurow Creek DIN mg/m3	Otiake DIN mg/m3	Otekaleke River DIN mg/m3	Maerewhenua DIN mg/m3	Awamoko DIN mg/m3	Welcome Creek DIN mg/m3
6/12/2006	2	3	7	6	6	236	60	8	2		21	76	2	635
13/12/2006	6	5	10	21	27	323	31	13	5	37	44	66	121	932
19/12/2006	3	3	7	13	11	298	26	7	2		134	83	6	849
2/01/2007	9	3	9	10	11	302	13	43	7	70	92	124	14	435
9/01/2007	2	2	6	5	7	208	4	20	2	21	68	178	6	320
16/01/2007	3	2	5	7	9	227	2	4	4	51	35	121	2	822
23/01/2007	15	2	3	5	7	236	3	5	6	3	26	148	2	430
7/02/2007	2	3	6	5	8	151	25	9			534	107	5	745
13/02/2007	7	2	6	5	7	244	40	8			37	69	2	781
21/02/2007	4	2	6	5	6	125	59	9			10	69	6	980
27/02/2007	5	5	6	7	8	169	123	6				74	3	789
6/03/2007	3	7	3	4	5	205	122	3				48	7	812
13/03/2007	3	3	9	10	9	298	144	3				131	17	568
20/03/2007	19	3	42	9	16	464	103	2				91	9	738
27/03/2007	7	7	10	9	11	297	203	6				82	8	846
3/04/2007	11	5	6	7	9	294	140	4				73	15	1023
<b>Max</b>	<b>19</b>	<b>7</b>	<b>42</b>	<b>21</b>	<b>27</b>	<b>464</b>	<b>203</b>	<b>43</b>	<b>7</b>	<b>70</b>	<b>134</b>	<b>178</b>	<b>121</b>	<b>1023</b>
<b>Min</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>125</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>21</b>	<b>48</b>	<b>2</b>	<b>320</b>
<b>Mean</b>	<b>6.3</b>	<b>3.6</b>	<b>8.8</b>	<b>8.0</b>	<b>9.8</b>	<b>254.8</b>	<b>68.6</b>	<b>9.4</b>	<b>4.0</b>	<b>36.4</b>	<b>60.0</b>	<b>96.3</b>	<b>14.1</b>	<b>731.6</b>
<b>Median</b>	<b>4.5</b>	<b>3</b>	<b>6</b>	<b>7</b>	<b>8.5</b>	<b>240</b>	<b>49.5</b>	<b>6.5</b>	<b>4</b>	<b>37</b>	<b>44</b>	<b>82.5</b>	<b>6</b>	<b>785</b>
<b>25% percentile</b>	<b>3</b>	<b>2</b>	<b>6</b>	<b>5</b>	<b>7</b>	<b>207.3</b>	<b>22</b>	<b>4</b>	<b>2</b>	<b>21</b>	<b>30.5</b>	<b>72</b>	<b>2.8</b>	<b>618.3</b>
<b>75% percentile</b>	<b>7.5</b>	<b>5</b>	<b>9</b>	<b>9.3</b>	<b>11</b>	<b>298</b>	<b>122.3</b>	<b>9.0</b>	<b>5.5</b>	<b>51.0</b>	<b>80.0</b>	<b>121.8</b>	<b>10.3</b>	<b>846.8</b>

Table 2: Statistical summaries for DRP data.

DRP mg/m3

Date Collected	Waitaki Dam	Kurow Ramp	Priest Rd	Duntroon Ramp	Stonewall	Waitaki Bridge	Awakino	Hakataramea	Kurow Creek	Otiake	Otekaieke	Maerewhenua	Awamoko	Welcome Creek
6/12/2006	1	1	1	1	1	3	4	2	2		1	2	12	8
13/12/2006	1	1	1	1	1	6	4	3	1	1	2	10	96	13
19/12/2006	1	1	1	1	1	1	1	1	1		18	1	4	3
2/01/2007	1	1	1	1	1	7	1	3	1	1	2	3	18	6
9/01/2007	1	1	1	1	1	1	1	1	1	9	1	2	20	4
16/01/2007	1	1	1	1	1	1	1	1	1	2	1	1	5	2
23/01/2007	1	1	1	1	1	1	1	1	1	1	1	1	6	2
7/02/2007	1	1	1	1	1	3	1	3			*	1	21	4
13/02/2007	1	1	1	1	1	8	1	3			4	3	30	5
21/02/2007	1	1	1	1	1	3	1	3			3	2	23	4
27/02/2007	1	1	1	1	1	13	1	3				1	20	4
6/03/2007	1	5	1	1	1	21	1	3				2	22	3
13/03/2007	1	1	1	1	1	10	4	3				29	90	16
20/03/2007	5	2	2	1	1	4	4	4				3	50	6
27/03/2007	1	1	1	2	1	3	2	1				5	74	7
3/04/2007	1	1	1	1	1	4	1	2				11	44	4
<b>Max</b>	5	5	2	2	1	21	4	4	2	9	18	29	96	16
<b>Min</b>	1	1	1	1	1	1	1	1	1	1	1	1	4	2
<b>Mean</b>	1.3	1.3	1.1	1.1	1.0	5.6	1.8	2.3	1.1	2.8	3.7	4.8	33.4	5.7
<b>Median</b>	1	1	1	1	1	3.5	1	3	1	1	2	2	21.5	4
<b>25% percentile</b>	1	1	1	1	1	2.5	1	1	1	1	1	1	16.5	3.75
<b>75% percentile</b>	1	1	1	1	1	7.25	2.5	3	1	2	3	3.5	45.5	6.25