Water Licence Requirements

Stave
Water Licence Requirement Reporting

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Turbidity Levels in Hayward Reservoir

Study Period: September 2005 - April 2006
Report Date: July 06

Turbidity Levels in Hayward Lake Reservoir

Year 1 (September 2005 – April 2006)

Summary Report

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for

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Executive summary

Under the terms of the Stave River Water Use Plan (WUP) and May 2004 Water Act order, the minimum operating elevation for Hayward Lake Reservoir was lowered to 39.5 m during spring and fall block loading generation conditions. Prior to the 2004 order the minimum operating level was restricted to 41.08 m. To assess potential impacts of increased drawdown zone exposure on the quality of water entering the District of Mission domestic water distribution system a decision was made to monitor the level of turbidity in the reservoir over the ten year WUP review period. Turbidity was measured every two months at six locations in Hayward Lake Reservoir from September 2005 to April 2006. Four sampling sessions have been completed in this first year of monitoring, and the results suggest that turbidity levels are on average 0.43 ± 0.28 NTU, well below the 1.0 NTU Canadian and provincial drinking water quality standard.

Acknowledgements

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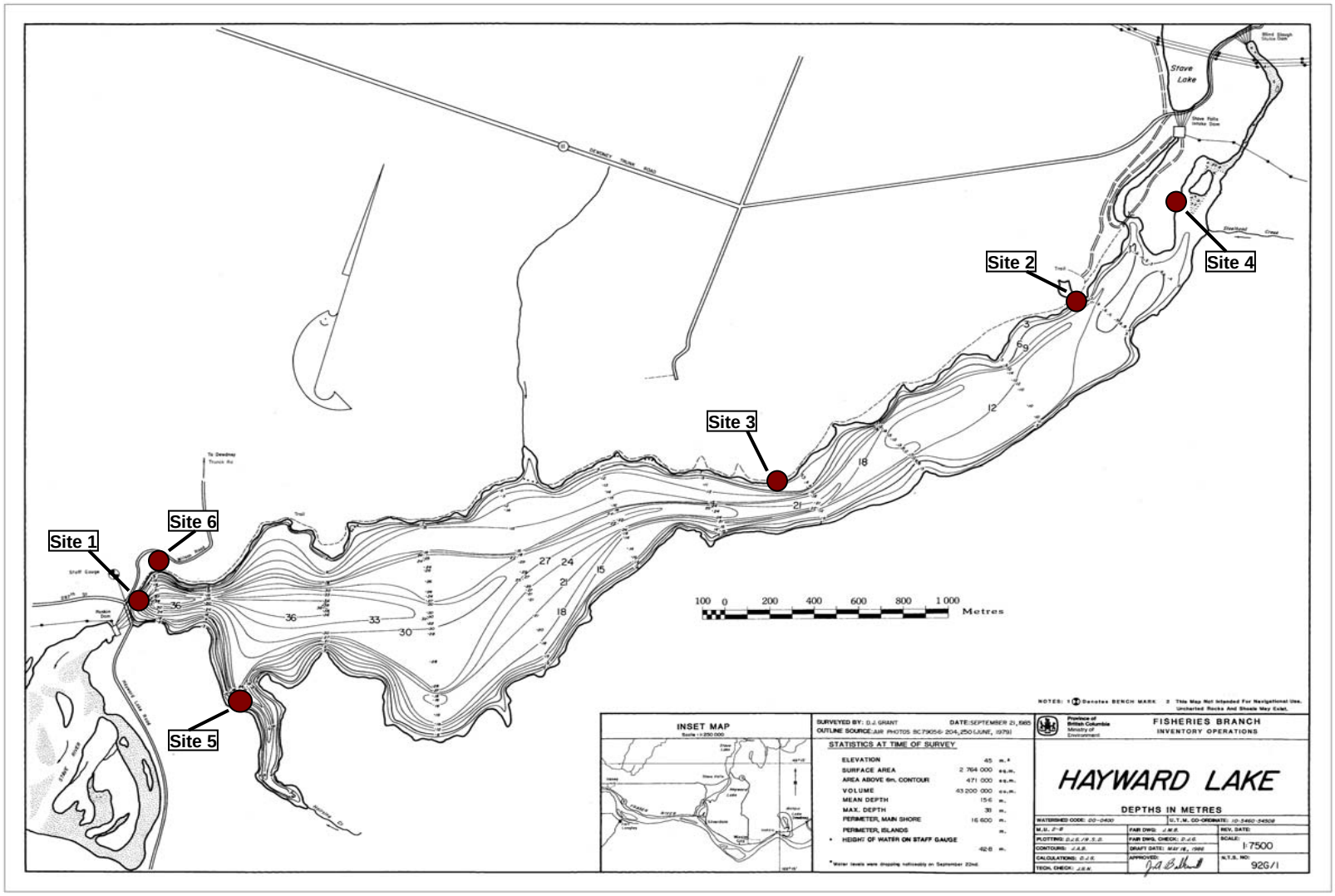
1.0 Introduction and Site Description

Operational in 1930, Hayward Lake Reservoir is part of the Stave Falls and Ruskin generating system that once supplied the Lower Mainland with the majority of its electricity. The reservoir has a surface area of 276 hectares, a storage volume of approximately 24 million cubic metres and a mean depth of 18 metres (Figure 1). Inflow to Hayward Lake Reservoir comes primarily from Stave Falls Reservoir, with minimal tributary inflow (BC Hydro 1998).

The terms of the May 2004 Water Act order permits the drawdown of Hayward Reservoir to 39.5 m during periods of fall (September 15 – November 30) and spring (February 15 – May 15) block loading when increased reservoir flexibility is required to maintain fisheries flows downstream of Ruskin Dam. During the Stave River Water Use Planning process some stakeholders suggested that the changes to the minimum operating elevation could negatively impact the water quality supply for the District of Mission who provide domestic water to local residents.

Turbidity is a measure of the relative cloudiness of water. The suspended solids and organic matter in turbid source water can increase pathogen loads and interfere with the disinfection of drinking water (GVRD Greater Vancouver Regional District 2005). Elevated levels may pose an increased health risk, as well as adding to a region or communities water filtration costs. This monitor is designed to test the source water turbidity of Hayward Lake Reservoir through out the year to ensure that the reservoir continues to meet provincial drinking water standards following the change to lower operating elevations.

Figure 1 – Bathymetric map of Hayward Lake Reservoir and surrounding tributaries showing locations of the six turbidity sample sites visited from September 2005, through to April 2006. Images with details of all sample sites are in located Appendix A.



2.0 Methods

Water samples were collected and assayed for turbidity from six locations around Hayward Lake Reservoir during September 2005 to April 2006 (Figure 1). Turbidity was measured using an Analite turbidity meter with readings in nephelometric turbidity units (NTU's). All sampling sessions were conducted during 10:00 and 13:00 hours on days when the previous day was free of precipitation events. Water samples were drawn in clear plastic sample vials at arms length from the shoreline at a depth of approximately 5-10 cm. Turbidity was assayed and recorded immediately following extraction. Three different samples were drawn, assayed, and averaged at each sample site. The turbidity meter was calibrated prior to each session and was compared to readings from the fixed location in-line turbidity meter located in the District of Mission pump house (see Appendix B, site 6).

Appendix A contains archive images of each sample location at the lowest reservoir elevation experienced during the 2005/06 sampling sessions (April 25, 2006 40.59 m). These images highlight the extent, condition and topography of the drawdown zone at each site.

3.0 Results

Canadian and provincial drinking water guidelines prescribe a turbidity standard of 1.0 NTU for untreated drinking water (Health Canada 2006). Higher source water turbidity levels are permissible if water is properly treated through filtration or disinfection and does not contain fecal coliform bacteria (Health Canada 2006).

3.1 Turbidity readings

All water quality sites sampled for turbidity showed consistent NTU readings across all sampling sessions. The cumulative average for all sites throughout the entire sampling period was 0.43 ± 0.28 (n=23) NTU, well below the Canadian and provincial 1.0 NTU standard (Table 1). The only sample site in Hayward Reservoir to exceed the 1.0 NTU threshold during the monitoring period was Site 5 on February 14, 2006 when turbidity was assayed at 1.58 NTU (Table 1). There is no obvious explanation for the high turbidity reading at this location during this sampling session as rainfall records show no precipitation for the previous 24 hours, and field notes do not indicate any noticeable erosion or disturbance at the reservoir foreshore. All raw turbidity data is presented in Appendix B.

Sample Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Mean (S.D)	Res. Elev. (m)	max. (m)	min. (m)	Range (m)
20-Sep	0.46	0.24	0.31	0.40	0.36	N.A.	**0.35 (0.08)**	42.16	42.39	41.59	0.80
23-Nov	0.27	0.50	0.39	0.28	0.40	0.39	**0.37 (0.08)**	40.61	40.91	40.30	0.61
14-Feb	0.51	0.33	0.52	0.60	1.58	0.36	**0.65 (0.47)**	41.21	41.22	41.18	0.03
25-Apr	0.19	0.56	0.18	0.36	0.57	0.25	**0.35 (0.18)**	40.59	40.67	40.55	0.12
Mean (S.D)	**0.36 (0.15)**	**0.41 (0.15)**	**0.35 (0.14)**	**0.41 (0.14)**	**0.73 (0.58)**	**0.33 (0.07)**	**0.43 (0.28) (n=23)**				

Table 1 – Averaged (n=3) turbidity measurements (NTU) recorded at six locations in Hayward Lake Reservoir during 2005/06 monitoring period. *Res. Elev.*, *max/min.* and *range* = reservoir elevations (m) for a 24 hour period preceding sampling

3.2 Reservoir elevations and precipitation

Reservoir elevation records demonstrate that the minimum elevation that Hayward Lake Reservoir reached during the turbidity monitoring period was 39.58 m. The reservoir level dropped to this height on February 16, 2006, and remained below 40.0 m for only nine hours (Figure 2). Precipitation throughout the monitoring period was typical for the region (*ie*. heavy rain in the fall and winter months) (Figure 3). Turbidity monitoring sessions were standardised to coincide with dry or periods of very little rainfall. Correlation relationships between precipitation and foreshore turbidity in Hayward Lake Reservoir were not evaluated during the 2005-2006 monitoring program.

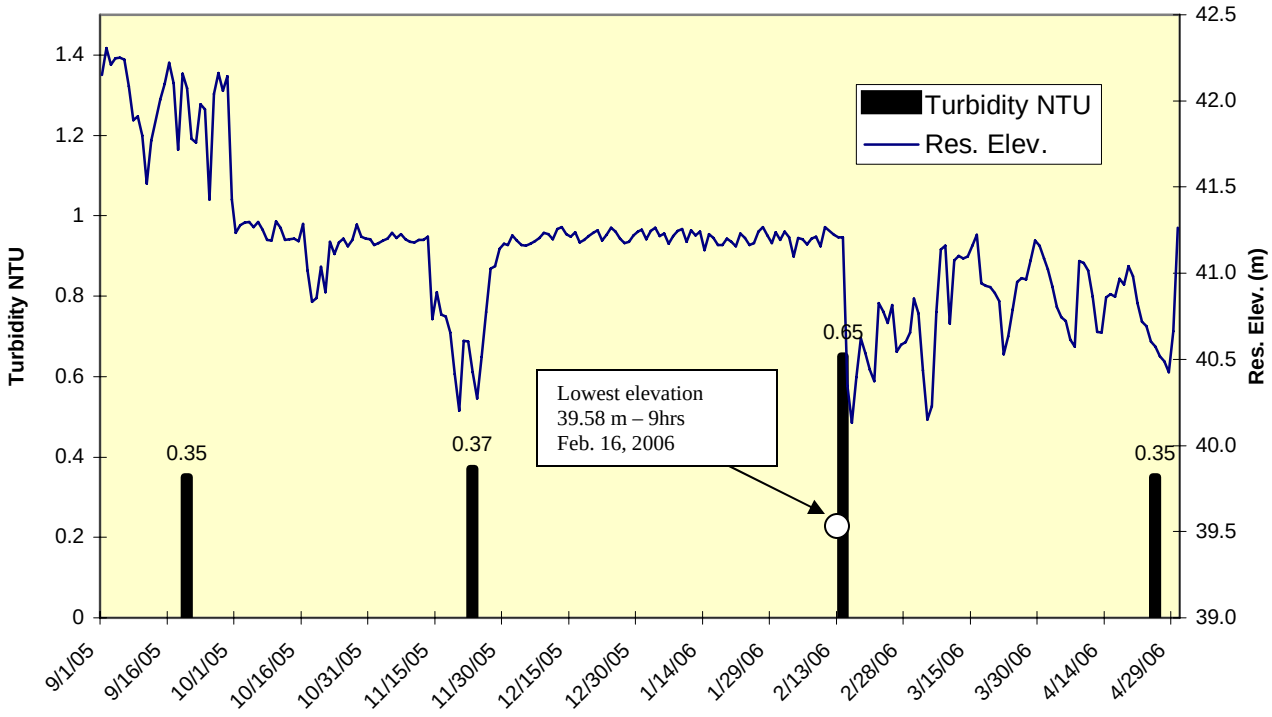


Figure 2 – Average daily Hayward Lake Reservoir elevation and averaged turbidity measurements, September 2005 – April 2006.

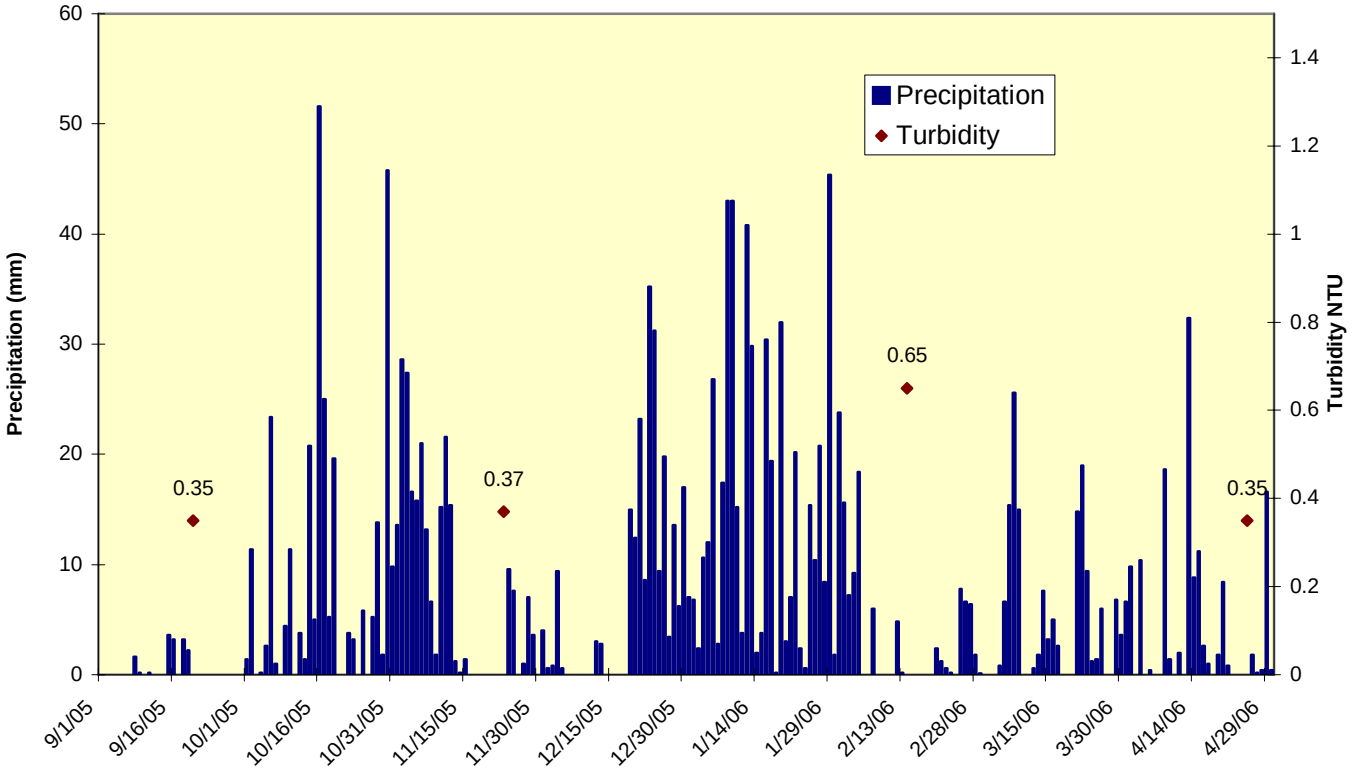


Figure 3 – Average daily precipitation at Haney, B.C. and averaged daily turbidity measurements at Hayward Lake Reservoir, September 2005 – April 2006.

4.0 Discussion

During periods of heavy weather with wind and precipitation inflows from foreshore and tributaries can increase reservoir turbidity levels (it should be noted that all sampling sessions were done under ideal conditions, *i.e.* calm wind conditions and without precipitation during the previous 24 hours). One sample location recorded turbidity readings greater than the British Columbia Provincial standard of 1.0 NTU on a single occasion, but over all the turbidity at Hayward Lake Reservoir averaged 0.43 ± 0.28 NTU during the monitoring period.

Turbidity readings that exceed the recommended 1.0 NTU guidelines are occasionally recorded among Greater Vancouver Region District (GVRD) drinking water intake sources, and these events are usually linked to precipitation and landslides (GVRD 2005). For example, the GVRD reports that in 2000, about 17% of daily samples from the Capilano Reservoir, 10% of those from Seymour Reservoir and 4% of those from Coquitlam Reservoir exceeded the 1.0 NTU standard (GVRD 2005). By comparison, data gathered during the four monitoring sessions performed on Hayward Lake Reservoir shows that only 4% of the samples exceeded the recommended guidelines.

The fact that there was only a very brief drop towards minimum reservoir levels over the course of the monitoring year, combined with the limited amount of data gathered in the first year of this monitor, suggests that conclusions about the impact of the new minimum operating level on reservoir turbidity cannot be made and future turbidity monitoring is needed to evaluate the potential consequences of lower reservoir drawdown elevations.

5.0 Conclusion and Recommendations

From the data gathered in this first year of turbidity sampling at Hayward Reservoir, it is possible only to conclude that under ideal conditions, the water in the reservoir meets Provincial and Federal standards with respect to raw, untreated drinking water. It is not yet possible to make conclusions regarding relationships between the new Hayward Lake Reservoir minimum operating level and turbidity.

For the upcoming monitoring year (May 2006- April 2007), some sampling sessions will be targeted to coincide with precipitation events. Sampling sessions should be varied to ensure that turbidity levels under different weather and precipitation conditions can be compared. In addition, a shoreline survey will be carried out to investigate areas of erosion around the lakeshore and monitor them for change. Areas of erosion may be exposed due to the new minimum operating level, which could potentially impact turbidity levels. No changes are recommended to the sampling sites as all were easily accessible and representative of the differing characteristics of the lakeshore.

6.0 Literature cited

BC Hydro Bridge Coastal Fish and Wildlife Program (1998). The Stave River Watershed, Volume 2, pp. 25.

Health Canada, March (2006). Guidelines for Canadian Drinking Water Summary Table, Federal-Provincial-Territorial Committee on Drinking Water, pp. 16

Greater Vancouver Water District (2005). Quality Control Annual Report, Volume II. Greater Vancouver Regional District pp. 177

7.0 Appendix A – turbidity sample location images

Site 1 Ruskin Dam Forebay: This site is located close to the Ruskin Dam, access is by foot from the Railway Trail parking lot. Shoreline area is concrete due to proximity to dam.

Site 2 Hayward Lake Reservoir Recreation Area: This site is located at the furthest downstream swimming area at the rec. site. The shoreline is exposed rock and soil, with little vegetation. Access is by foot.

Site 3 Mid Hayward Lake Reservoir: This site is accessed by vehicle, a 1.7km drive from the Hayward Lake Recreation Area site 2. Shoreline is heavily vegetated with shrubs and trees.

Site 4 Downstream of Stave Falls Tailrace: This site is accessed on foot from the recreation site and is approximately 400m downstream of the Stave Falls tailrace. The shoreline is boulder strewn and well vegetated.

Site 5 East Shore Hayward Lake Reservoir: This site is accessed on foot from the East side of the road that crosses Ruskin Dam. A ten minute walk along the Reservoir Trail takes you to this site, located at a floating bridge that crosses a section of the reservoir. Shoreline is well vegetated with trees and shrubs.

Site 6 Saw Water from District of Mission Pump House: This site is adjacent to site 1 and is also accessed on foot from the Railway Trail parking lot. Samples are drawn directly from the untreated saw water taps within the pump house.

8.0 Appendix B – raw turbidity measurements and sample location UTM coordinates

Site 1					
Ruskin Forebay					
UTM	0541666				
	5446548				
Sample #	1	2	3	avg	
NTU	0.30	0.37	0.70	**0.46**	20-Sep-05
	0.33	0.29	0.19	**0.27**	23-Nov-05
	0.54	0.72	0.26	**0.51**	14-Feb-06
	0.29	0.08	0.21	**0.19**	25-Apr-06
Cumulative Average				**0.36**	

Table 1 Site 1 data record for all sampling sessions

Site 2					
Hayward rec. site					
UTM	0543154				
	5449429				
	1	2	3		
Turb. (NTU)	0.31	0.2	0.22	**0.24**	20-Sep-05
	0.60	0.41	0.48	**0.50**	23-Nov-05
	0.51	0.21	0.28	**0.33**	14-Feb-06
	0.46	0.81	0.41	**0.56**	25-Apr-06
Cumulative Average				**0.41**	

Table 2 Site 2 data record for all sampling sessions

Site 3					
Hayward mid lake rb					
UTM	0544751				
	5450609				
	1	2	3		
Turb. (NTU)	0.25	0.38	0.29	**0.31**	20-Sep-05
	0.67	0.46	0.05	**0.39**	23-Nov-05
	0.19	0.72	0.64	**0.52**	14-Feb-06
	0.06	0.39	0.08	**0.18**	25-Apr-06
				0.35	

Table 3 Site 3 data record for all sampling sessions

Site 4
D/S Stave tailrace
UTM 0544754
5450611

	1	2	3		
Turb. (NTU	0.55	0.14	0.50	**0.40**	20-Sep-05
	0.60	0.10	0.15	**0.28**	23-Nov-05
	0.20	0.97	0.63	**0.60**	14-Feb-06
	0.24	0.38	0.46	**0.36**	25-Apr-06
Cumulative Average				**0.41**	

Table 4 Site 4 data record for all sampling sessions

Site 5
L/B U/S of forebay Floating Bridge
UTM 0543656
5449281

	1	2	3		
Turb. (NTU	0.63	0.23	0.21	**0.36**	20-Sep-05
	0.30	0.40	0.49	**0.40**	23-Nov-05
	1.74	1.25	1.75	**1.58**	14-Feb-06
	0.58	0.72	0.40	**0.57**	25-Apr-06
Cumulative Average				**0.73**	

Table 5 Site 5 data record for all sampling sessions

Site 6
saw water in pump house

	1	2	3		Pump House Meter	
Turb. (NTU	n/a	n/a	n/a			20-Sep-05
	0.63	0.30	0.23	0.39	0.292	23-Nov-05
	0.28	0.10	0.36	0.25	0.285	14-Feb-06
	0.33	0.09	0.33	0.25	0.232	25-Apr-06
Cumulative Average				**0.32**		

Table 6 Site 6 data record for all sampling sessions, includes recording from pump house for comparison to turbidity