WATER SUPPLY AND WATER QUALITY MONITORING IN HOMATHKO RIVER BASIN

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By Sandy Hart, P. Geo.,
J.S. Hart and Associates Ltd., Tatla Lake, BC

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1.0 INTRODUCTION

The Nature Conservancy of Canada (NCC) has an interest in maintaining high water quality and adequate water supply in the upper Homathko basin, both for human use and for protection of aquatic habitat. This study was initiated by NCC to provide baseline hydrologic information that could be used for analysis of trends in water quality and supply and for evaluation of potential impacts on water resources. Hydrologic data will also serve as a foundation for further scientific research in the basin, a function which the Nature Conservancy is undertaking to support.

In rural basins without intensive land uses (such as feedlots or high density subdivisions), the causes of water quality deterioration are typically numerous, individually minor, and widely dispersed. For example, sources of sediment related to land use activities can be disturbed channel banks, exposed field soils, compacted surfaces, roads, and drainage and irrigation ditches. Because rural water quality declines due to additions from many such sources, it is difficult for government agencies to regulate practices to maintain water quality. The most effective watershed management occurs where community residents take the responsibility upon themselves. In fact, there's little likelihood of maintaining high water quality without active local involvement. To be successful at this effort, knowledge of the nature and magnitude of water supply and water quality conditions is required.

An additional cause of water quality and water supply change in the Homathko basin will be climate change. A warming climate could result in hydrologic effects such as an increasing proportion of winter precipitation as rain, earlier spring runoff, diminishing meltwater supply from alpine snowpatches and glaciers, and a prolonged summer low flow period with warmer temperatures causing higher rates of evaporation and transpiration (e.g., h*ttp://www.env.gov.bc.ca/air/climate/indicat/timevol_id1.html* for further information). As has been found elsewhere in the province (Leith and Whitfield, 1998), such changes may already be underway in the Homathko basin. Climate change could place increasing pressure on water resources and necessitate especially careful water management practices.

As a landowner in the basin, and having a particular interest in water conservation, the NCC is seeking to collect information about current water quality and water supply conditions in order to support their own and other landowners' efforts to protect this resource. The objectives of this year's program are the following:

- to measure precipitation variation within the basin at snowcourses and rain gauges located to supplement the existing network of stations;
- to collect baseline watershed hydrology and water quality data at representative stations;
- to establish a water quality laboratory and analyze selected parameters for samples collected; and
- in a final report, to provide a description of the Homathko basin, to report the 2006 season's research methods, and to present analyses of the hydrometeorologic and water quality data.

2.0 DESCRIPTION OF STUDY AREA

2.1 LOCATION AND AREA

The upper Homathko River basin is located in the Chilcotin, approximately 200 km west of Williams Lake. Road access is south along Tatlayoko Road from Hwy. 20 at Tatla Lake.

The entire drainage basin area upstream of the outlet of Tatlayoko Lake is 975 km²; of this area, the basin upstream of the lake is 498 km² and the Cheshi Creek/Stikelan Creek basin is 192 km² (see Figure 1).

2.2 PHYSIOGRAPHY

Homathko River, flowing southward to Bute Inlet, is the first watercourse north of Fraser River to cut directly through the Coast Mountains to the Pacific coast. In its upstream reaches, the Homathko drains Tatlayoko Lake, the settled Tatlayoko Valley upstream of the lake, the eastern slopes of the Niut Range, the western flank of the Potato Range, and a lower-relief area of the Chilcotin (or Fraser) Plateau (see Figure 1). The basin drained by Tatlayoko Lake thus encompasses a broad range of physiographic and ecologic settings: from the continental Plateau to Coast Mountain environments influenced by proximity to the ocean; and from low-elevation valley bottoms to alpine peaks.

Local relief along Tatlayoko Valley ranges from 827 m at the lake to the 2,206-metre summit of the Potato Range on the east and on its western side to 2,895-metre Niut Mountain in the Niut Range. Elevations on the northern watershed divide of Splinter Ridge reach 1,750 metres.

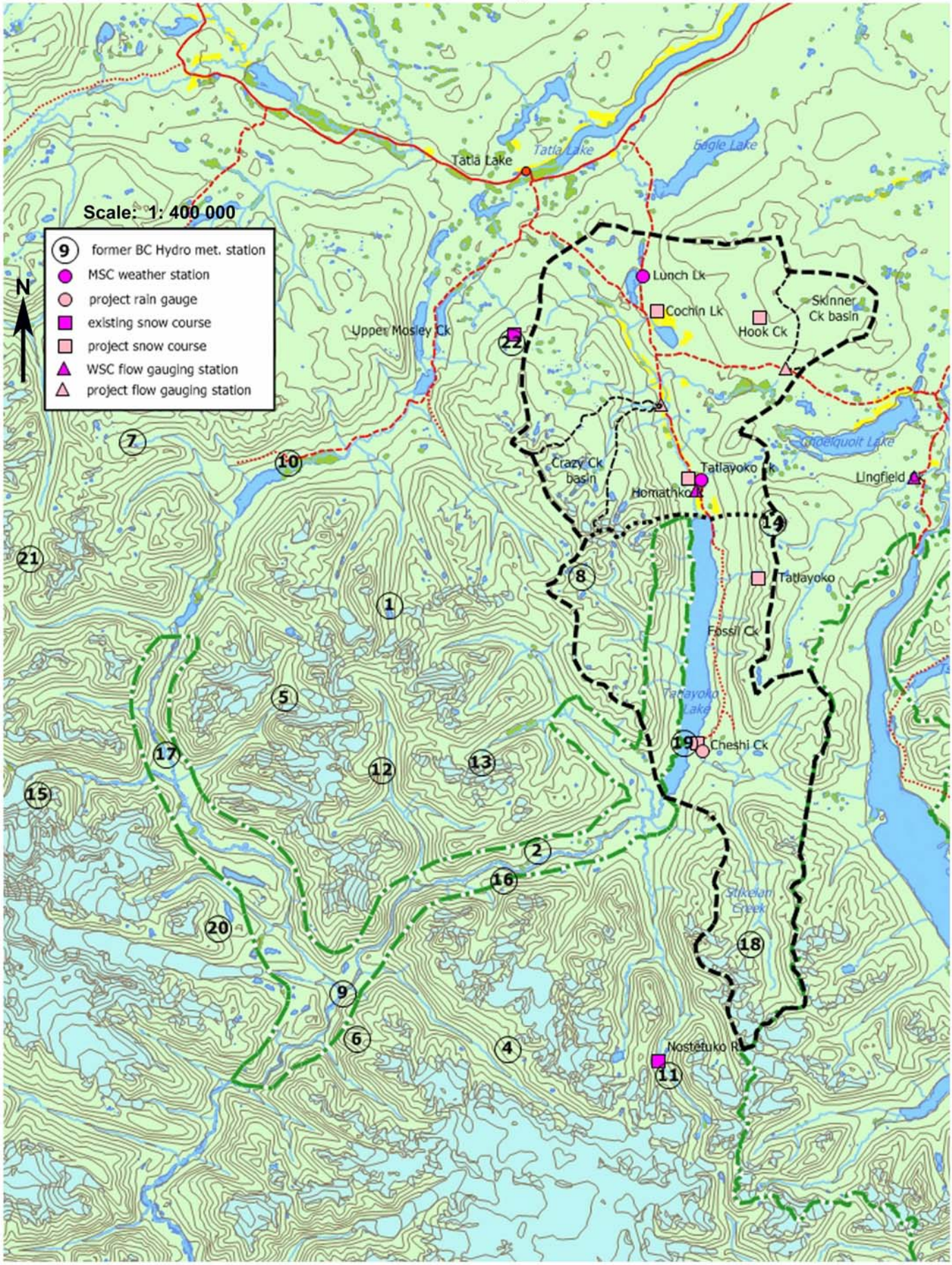
The bedrock geology of the Homathko basin is complex: the Niut Range includes areas of plutonic, volcanic, and minor sedimentary rock; the Potato Range is underlain by sedimentary rock; Skinner Mountain on the east side of Tatlayoko Valley is plutonic rock; Splinter Ridge (drained by Cochin Creek) is mainly plutonic and metamorphic rock; and Skinner Creek basin is underlain by volcanic rock (Roddick and Okulitch, 1973; Schiarizza et al., 2002).

Tatlayoko Valley, the lower slopes of the Niut Range, Potato Range, and Skinner Mountain, and most of the Plateau portion of the basin are covered by unconsolidated deposits. Glacial till and fluvio-glacial, alluvial, and colluvial materials are most extensive. There are also minor bedrock exposures as well as lacustrine and organic deposits in low-lying areas and wetlands. At higher elevations, surficial materials are primarily glacial till and colluvial deposits with widespread exposed bedrock.

2.3 CLIMATE

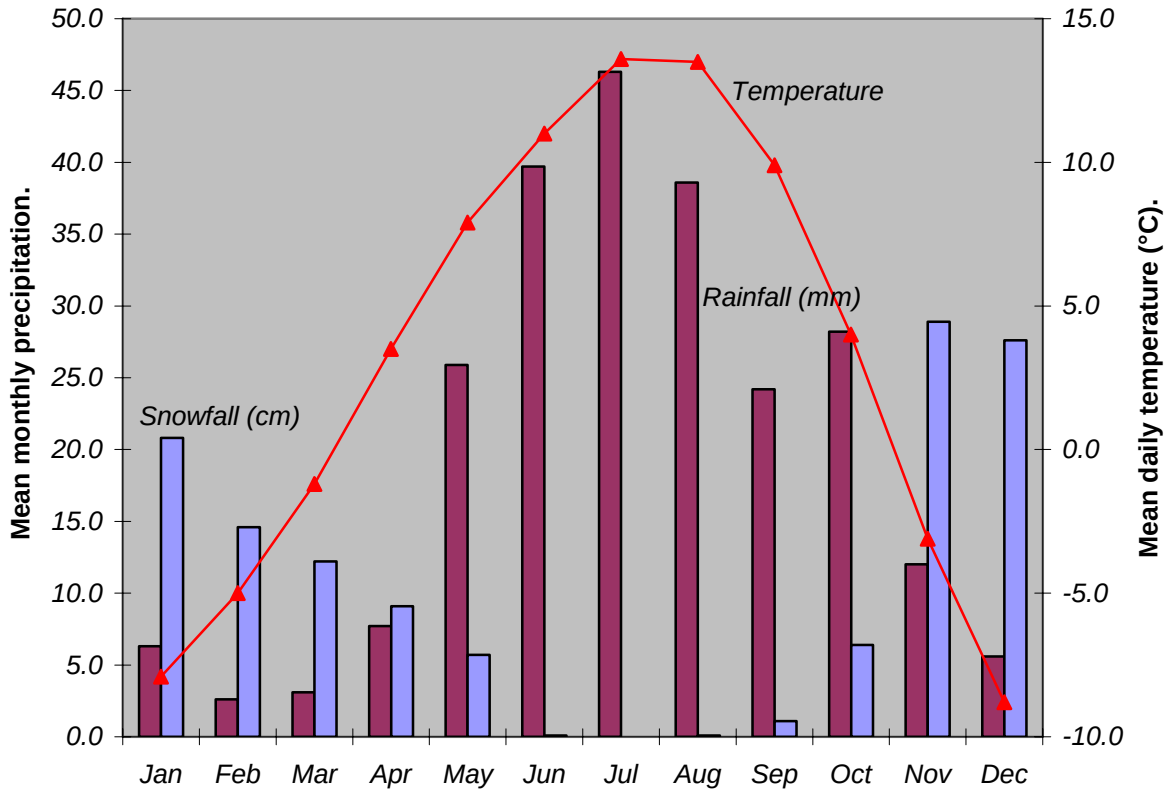
The study area has a cool continental climate moderated by its proximity to the coast. This maritime influence causes slightly warmer winters and cooler summers than locations at similar elevations further inland. Annual daily temperatures for the 1980-2002 period at the Lunch

Figure 1. Homathko basin hydrometric network.



Lake weather station (1017 m) are 3.0°C, ranging from -8.8°C in December to 13.6°C in July (see Figure 2). For the same period at the Tatlayoko Lake weather station (853 m; 17.5 km to the south) annual daily temperatures are 4.2°C, with a range from -6.5°C in December to 13.7°C in July (Meteorological Service of Canada on-line archive).

Figure 2. Lunch Lake precipitation and temperature, 1980-2002.



Being situated in a 'rainshadow' on the leeward side of the Coast Mountains, the study area climate is relatively dry with precipitation decreasing northward with distance from the crest of the Range. Annual precipitation amounts at the Environment Canada Lunch Lake and Tatlayoko Lake stations are 374.8 mm and 465.9 mm respectively; of these totals, the average proportions as snow are 34% at Lunch Lake and 28% at Tatlayoko Lake. At the south end of Tatlayoko Lake, annual valley bottom precipitation is estimated to be twice the valley amounts recorded at the north end of the basin. Similarly, the water equivalent of the accumulated winter snowpack near treeline ranges from a 280 mm average at the Upper Mosley Creek station (1650 m) to 572 mm at the Nostetuko River station (1500 m) (Ministry of Environment, on-line archive, 16-18 yr record).

Hawes (1984) mapped the pattern of snowmelt in the Homathko River basin using Landsat imagery. Below treeline and on south-facing alpine slopes snowmelt occurs generally from mid-April to late May. For most alpine areas the snowmelt period is May and June. Some of the

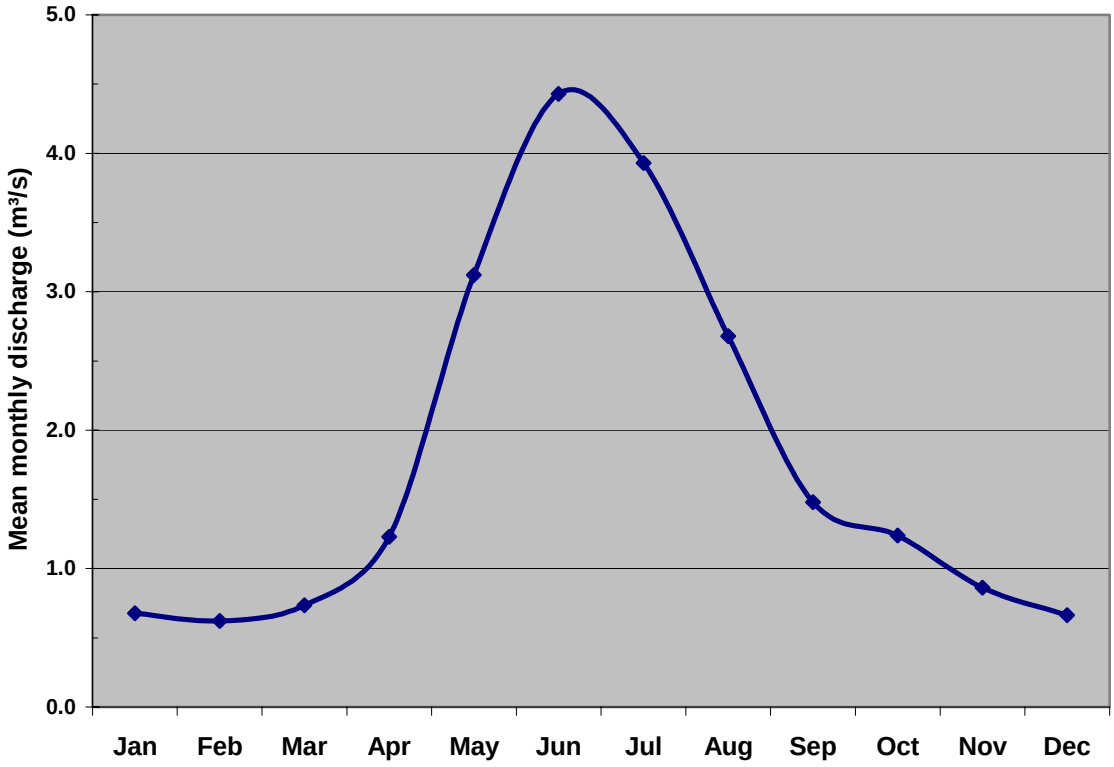
highest elevation areas, particularly on north-facing slopes, retain snowpatches throughout the summer.

2.4 STREAMFLOW REGIME

The flow regime of streams in the Homathko basin is dominated by meltwater discharge that begins with low elevation snowmelt runoff in late March and peaks between April and July, depending on basin elevation, size, and meltwater source. The smaller, lower-elevation basins have peak flows in April and May. Streams draining high-elevation basins peak in June with snowmelt runoff or during July where alpine glaciers and snowpatches dominate the meltwater supply.

The hydrograph for the Homathko River gauging station above Tatlayoko Lake illustrates the seasonal flow regime typical of the larger streams (Figure 3). Although meltwater accounts for the maximum annual discharge volume, the annual peak streamflow is frequently produced by large rainstorms. Through the period of record 35 percent of the annual peak daily flows have occurred between July and October and are assumed to be associated with rainstorm events.

Figure 3. Homathko River monthly hydrograph, 1968-2003 (WSC Station 08GD008)



Many small, low-elevation streams in the study area flow only during snowmelt or decline to very low flows through the summer. Flows of the larger perennial streams have minimum flows

during late summer and early fall followed by slight flow increases in late fall due to reduced evapotranspiration.

2.5 VEGETATION

With the study area's variable climate, terrain, and elevation, vegetation zones are diverse. Ascending from the lower valley, biogeoclimatic zones range from the Interior Douglas Fir Zone, through Montane Spruce and Engelmann Spruce Subalpine Fir Zones, to Alpine Tundra. Southward along the main valleys there is a transition from the dry Sub-boreal Pine Spruce Zone (Very Dry Cold Subzone) of the Chilcotin Plateau through progressively wetter forest of Dry Cool to Dry Warm Subzones of the Interior Douglas Fir Zone (Steen and Coupé, 1997).

In the alpine and subalpine zones vegetation is less productive than in moister climates; however, areas of meadowland and open subalpine fir, lodgepole pine and whitebark pine forest are common. Treeline elevation is typically in the range 1,800-2,000 metres. Middle elevations are dominated by open lodgepole pine and minor subalpine fir forest with spruce forest on moister sites. Lower elevation forest vegetation consists mainly of old and mature Douglas fir, mixed-age lodgepole pine, and localized aspen stands on drier sites and spruce with minor aspen and cottonwood on wetter sites. At the southern end of Tatlayoko Lake Western Red Cedar is encountered and downstream, beyond the study area, the Coastal Western Hemlock zone is present.

2.6 LAND USE

2.6.1 Agriculture

Cattle ranching and hay farming are the main land uses in the settled areas of Tatlayoko and Valley. Most ranches are operated as cow-calf operations with livestock being turned out on Crown range from mid-May to end October while ranch land is used for hay production. Some operators maintain cattle on deeded pasture through the grazing period and others grow hay only, mainly to supply local demand.

In addition to these operations there are numerous smaller operators raising livestock or crops for personal or local use and consumption. Such operations include small mixed farms, a commercial greenhouse, and horse breeders.

2.6.2 Commercial and public recreation

Commercial recreation is a second important land use in the Tatlayoko Valley. Long-established tourism operations rely primarily on the area's outstanding backcountry recreation opportunities. Services and activities offered include tourist accommodation, guide-outfitting, horse trips, hiking, skiing, snowboarding, angling, and mountaineering.

Public recreationists are increasingly drawn to the area for the activities listed above as well as other pursuits such as mountain biking, windsurfing, kayaking, and snowmachining. As the

range of support services expands and the area becomes better known, the presence of public recreationists will increasingly contribute to the community economy.

2.6.3 Residential use

While ranching and commercial recreation are the most extensive land uses, a majority of residents rely on income from sources that are not directly based on land tenures or large holdings. These sources include carpentry, fine woodworking, general contracting, heavy equipment operation, teaching, health services, retail services, video and website production, bus and truck driving, arts and crafts, logging, environmental consulting, silviculture contracting, and retirement income. Although these activities depend to varying degrees on natural resources, most people who have moved to the area have done so because of the exceptional landscape and recreational opportunities available.

2.6.4 Forestry

In Tatlayoko Valley small-scale logging has been carried on by residents for many decades to supply small, local sawmills, for building and fence construction, and other ranch purposes. This logging was loosely regulated and the dispersed, selectively-logged areas do not appear on forest cover maps.

Industrial logging commenced in 1964 with establishment by Lignum Ltd. of a sawmill on the Tatlayoko lakeshore. Clearcut logging of Douglas fir forest was carried out mainly along the east side of the lake, but also in small areas on the west lakeside and on the west side of the main valley just upstream of the lake. Logging and milling along Tatlayoko Lake ceased in 1975 when the mill burned down.

Also during this period (mainly from 1969-70) Pinette and Therrien Mills Ltd. was logging Douglas fir in the upper Homathko basin in the vicinity of Lunch Lake. These logs were hauled to their mill at Chilanko Forks.

In the past 20 years a limited amount of logging has been carried out, principally in pine forest in the northern portion of the basin. Clearcut blocks are located in Skinner Creek basin, Cochin Creek basin, and in headwaters of Homathko River on the northern slopes of the Niut Range.

2.6.5 Mineral exploration and mining

Mineral exploration and mining activities have taken place in the Tatlayoko Valley throughout the century. Prospecting for gold commenced in the early 1900's and four small gold mining operations were developed in the 1930's: the Morris Mine on Langara Mtn. at the south end of Tatlayoko Lake being the largest operation; and the Feeney, Rafferty, and Blackhorn Mines in the Niut Range. There is still interest in the mineral potential of the Niut Range and Tatlayoko Valley; although there are no operating mines as yet, Skinner Mountain Mine in Tatlayoko Valley has shipped bulk gold ore samples.

2.7 WATER USE

Because of low growing season precipitation, licensed use of surface water for irrigation is particularly important to the agricultural operations. Water is diverted for irrigation use during the growing season from Homathko River and its tributary streams and it is withdrawn for storage in reservoirs during the period October 1 to June 15 or 30.

Water use is also licensed for domestic consumption and livestock watering throughout the year.

2.8 FISH PRESENCE

Based on available Ministry of Environment and Department of Fisheries and Oceans online records and on a G3 Consulting Ltd. (1999) fish habitat assessment, 'target' fish presence has been recorded as follows: rainbow trout, bull trout, and Dolly Varden char in Tatlayoko Lake; rainbow trout, cutthroat trout, bull trout, and Dolly Varden in the Homathko River mainstem (above the lake); rainbow trout in Quakie Creek (Homathko headwaters); rainbow trout and bull trout in Cochin Lake and upstream in Cochin (McGhee) Creek; and rainbow trout, cutthroat trout, bull trout, and Dolly Varden in the lowest reach of Skinner Creek as well as rainbow trout in a mid-basin reach at the Chilko Road crossing.

Numerous additional streams tributary to Homathko River and Tatlayoko Lake are mapped by G3 Consulting Ltd. as 'suspected fish-bearing' based on aerial photo and map measurement of stream gradient; however, field surveys of fish presence have not been carried out.

3.0 METHODS

3.1 CLIMATE

Climate data are available from existing stations, both past and present. To supplement these data for this study, additional snowcourse and rain gauge stations were established.

The Meteorological Service of Canada maintains weather stations at two low-elevation locations in the Homathko basin (see Figure 1). The Tatlayoko Lake manual station, in operation since 1928, has been replaced with a nearby automated station.

- *Tatlayoko Lake* (inactive) - manual station; Lincoln Creek Ranch, 51° 40'25", 124° 24'9", 875 m; in operation 1928 to 2004; temperature and precipitation.
- *Tatlayoko Lake RCS* - automated station; Lincoln Creek Ranch, 51° 40'28", 124° 24'1", 870 m; in operation since August, 2000; temperature, precipitation, and intermittent record of wind speed and direction.
- *Lunch Lake*, manual station (operated by Helen Schuk); Lunch Lake, 51°49'30", 124°27'51", 1917 m; in operation Nov. 1980 to present; temperature and precipitation.

The BC Ministry of Environment has past and present snowcover data for three locations:

- *Tatlayoko Lake* (inactive) - manual station; northwest, sub-alpine slope of Potato Mountain, 51°36', 124°20', 1710 m; 1952-1998; snow depth and water equivalent.
- *Upper Mosley Creek* - automated snow pillow station; Mosley Creek basin near Homathko headwaters, sub-alpine location, 51°47', 124°37', 1650 m; 1989 to present; snow water equivalent.
- *Nostetuko River* - automated snow pillow station; upper Nostetuko River basin, sub-alpine location, 51°15, 124°27, 1500 m; 1989 to present; snow water equivalent.

The following snowcourses and manual rain gauges were established for this study.

- *Hook Creek* - manual snowcourse station; 51°47'38", 124°19'56", 1525 m; surveyed 30 March 2006; snow depth and water equivalent.
- *Cochin Lake* - manual snowcourse station; 51°48'2", 124°26'50", 1000 m; surveyed 16 March 2006; snow depth and water equivalent.
- *Tatlayoko Valley* - manual snowcourse station; 51°40'32", 124°25'0", 860 m; sampled 16 March 2006; snow depth and water equivalent.
- *Tatlayoko Lake* - Ministry of Environment manual snowcourse station as listed above. Although officially inactive since 1998, local residents Fritz Mueller (the former snow surveyor) and Bob Sagar have surveyed the snowcourse close to April 1 from 1999 to the present (with the exception of 2000 and 2001). Bob Sagar and the writer surveyed the course on 31 March 2006.
- *Cheshi Creek* - manual rain gauge station; 51°24'44", 124°24'44", 830 m; sampled monthly.
- *Cheshi Creek* - manual snowcourse station; 51°28'34", 124°24'25", 833 m; surveyed 25 March 2006.

BC Hydro maintained a network of 23 climate stations throughout the Homathko and Mosley Creek basins (see Figure 1) during the late 1980's and early 1990's (in most cases from 1988-1994). These stations were situated through a range of elevations to provide climatic data for a proposed Homathko hydroelectric power project. Almost all the stations provide temperature and precipitation data, and several stations recorded additional parameters such as wind speed and direction, humidity, and solar radiation. Following cancellation of the power project, operation of the stations was suspended. BC Hydro has made available to NCC the raw data collected at these stations; however, no summaries or data analyses have been produced (Fast, pers. comm.).

3.2 STREAMFLOW

The area of interest for this project is the basin draining into Tatlayoko Lake upstream of its outlet at the south end of the lake; however, for 2006, the water monitoring program focused on the basin upstream of the Homathko River inlet to the lake.

Two tributary basins were selected for monitoring - Crazy Creek and Skinner Creek basins - which are similar in size, representative of the diverse basin terrain, relatively unaffected by land development, and have no upstream water withdrawal for irrigation or other uses. At each of these stations manual flow gauging stations were established.

Homathko River was also monitored at Mueller's bridge, just upstream of NCC's Tatlayoko Ranch. At this station no discharge measurement was required, since it is located immediately downstream from the Water Survey of Canada (WSC) hydrometric station (Station 08GD008). The WSC station is equipped with an automatic stage (height of flow) recorder which is calibrated by stage-discharge rating curve to produce a continuous record of discharge. From 1968 to 1975 the station was operated from May to September only; and from 1982 to the present it has been operated year-round.

At the Crazy Creek and Skinner Creek stations stage was measured from an overhead reference mark at each visit. Stream velocity was measured by Price 622AA current meter. Hydrometric survey procedures were designed to meet Class C standards set out by the Ministry of Environment, Lands and Parks (1998) for manual stations. Preparations were made for dry injection salt dilution gauging (Hudson and Fraser, 2005) for higher flows in Crazy Creek; however, flows requiring this method were not attained.

At Crazy Creek, stage was measured by leveling rod from a reference mark on a bridge timber to a pool surface below. The reference mark elevation has been surveyed together with two off-channel benchmarks (see Appendix 1). The channel cross-section impounding the pool was also surveyed to monitor cross-sectional change for purposes of rating curve calibration in 2007.

At Skinner Creek, stage was measured from an overhead reference mark to the water surface at the road culvert outlet. Culvert outlet water level is maintained by a sandbag weir, apparently constructed to maintain a pool for livestock watering. This weir was left intact, since a sufficiently high timber weir at the site might impede fish passage. Water depth was also measured at a cross-section within the culvert at which water flows are unaffected by the

downstream impoundment. The culvert slope at this cross-section was surveyed to allow calculation of flow based on culvert geometry, in order to confirm the direct discharge measurements (see Appendix 1).

Rating curves relating discharge to stage are defined for each station. These relationships are applied to all stage measurements to produce the corrected discharge values presented in this report.

The flow monitoring schedule was once weekly from March 29 to July 19, thence bi-weekly until October 22.

3.3 WATER QUALITY

The water quality parameters selected for measurement are those which are most indicative of impacts upon aquatic habitat and water quality for human uses.

The following point measurements were made during each site visit: turbidity using a *LaMotte 2020E Turbidimeter*; and conductivity, temperature, and pH using a *YSI Model 63 Handheld pH, Conductivity, Salinity and Temperature System*.

Grab samples were taken in 1000 ml bottles for lab analysis of total suspended and dissolved solids. Replicate samples were taken every 20 samples. Lab procedures for analysis of total suspended and dissolved solids are outlined in Appendix B.

For a one month period (March 18-April 16) during valley-bottom snowmelt, 1000 ml samples were taken twice a day for two days each week at the Homathko sampling station (by Fritz Mueller). These samples were frozen and later shipped to Cantest Ltd. (Burnaby) for analysis of total phosphorus, total suspended solids, and total dissolved solids.

4.0 RESULTS AND DISCUSSION

4.1 CLIMATE

Snowcover data prior to snowmelt for the 2006 season are presented in Table 1. For the 18 and 16 year snow pillow data records at Upper Mosley Creek and Nostetuko stations (respectively), April 1 snow water equivalent amounts were 86% and 88% of normal, similar to conditions elsewhere in the southern Coast Mountains (http://www.env.gov.bc.ca/rfc/ archive/). The Tatlayoko Lake station on Potato Mountain was 65% of normal. On the other hand, Chilcotin Plateau snowcover was relatively low, with Puntzi Mountain reporting an April 1 snow water equivalent at 39% of normal.

Table 1. Homathko basin snowcover data, spring 2006.

Station	Date	Mean depth (cm)	Mean water equivalent (mm)		Years of record
			2006	Record period	
Mueller	16-Mar	34.3	77	-	1
Cochin	16-Mar	31.1	61	-	1
Cheshi Creek	25-Mar	47.2	109	-	1
Hook Creek	30-Mar	55.3	122	-	1
Upper Mosley*	1-Apr	-	240	280	18
Nostetuko*	1-Apr	-	503	572	16
Tatlayoko Lake	31-Mar	68.7	165	258	47

*** Online data source: http://www.env.gov.bc.ca/rfc/archive/2006/200604/coastal.html**

The summer of 2006 was extremely dry, with a June-August rainfall total of only 25.4 mm and no significant runoff-producing rainstorms occurring. This rainfall amount is less than all but two years since observations began in 1928: the summer of 1933 was significantly drier at 18.0 mm; and, in 1967, summer rainfall was comparable at 24.2 mm. Table 2 presents the data for the April-October, 2006 period of record.

Table 2. Homathko basin rainfall data, 2006.

Period	Rainfall amount (mm)			
	Cheshi Creek	Cochin Lake	Lunch Lake	Tatlayoko Lake
April	-	-	21.0	11.4
May	-	-	22.8	24.0
24-31 May*	27.0	32.0		(22.6)
June	1.8	3.0	15.4	7.6
July	0.0	7.4	9.8	7.8
August	1.2	8.1	6.6	10.0
September	13.8	31.9	28.0	44.0
October	81.0 (to Nov 7)	34.7 (to Nov 5)	35.0	28.0

***Cheshi and Cochin gauges installed 24 May - amounts listed for comparison purposes.**

4.2 STREAMFLOW

4.2.1 Stage-discharge rating curves

Stage-discharge rating curves defined for Skinner Creek and Crazy Creek are shown in Appendix C. Both relationships are strong, with regression coefficients of 0.99. The channels would be re-surveyed at the beginning of next field season to verify rating curve applicability.

An additional rating curve has been constructed for the interior culvert cross-section at Skinner Creek. This curve also has a regression coefficient of 0.99. It has been defined for use in the event of a change of water level at the culvert outlet.

4.2.2 Flow regime

The Homathko River hydrograph is from preliminary data provided by the Water Survey of Canada (Campo, pers. comm.). The seasonal hydrographs constructed for Crazy Creek and Skinner Creek are based on discharge corrected to the rating curves (Appendix D).

In Homathko River low-elevation snowmelt peak occurred in late March-early April. The year's highest flows were in late May and June in response to high elevation snowmelt. Streamflows were moderate through July and declined through August to lowest flows in early September. Later fall flows increased in response to increased precipitation and decreased evapotranspiration[1].

The 2006 peak daily flow of 5.54 m^3/s (21 May) is the fourth lowest of the Water Survey of Canada flow record from 1968-2005 (http://www.wsc.ec.gc.ca). In a flood frequency analysis this flow level would have a recurrence interval of little more than a year; that is, it would be equaled or exceeded in most years.

In Skinner Creek the snowmelt runoff peak occurred in late April and early May. The secondary peak in late May was due to rainfall during the period May 24-31 (totaling 32 mm at the Cochin Lake gauge). Discharge declined slowly through the very dry period of June, July, and August. The slight increase in September and October is related to increased precipitation and decreased evapotranspiration.

Crazy Creek snowmelt discharge increased sharply in mid May and peaked in mid June. An early July peak occurred with increased high elevation snowpack and glacier melt. Discharge declined sharply in mid July, followed by a gradual decline through the summer and fall as the seasonal high elevation snowpack diminished.

[1] At the time of writing the Water Survey of Canada's October discharge data for Homathko River were not yet available.

4.3 WATER QUALITY

4.3.1 Snowmelt period phosphorus yield

In Figure D1 (Appendix D) a late March-early April rise in the Homathko River hydrograph is apparent, attributed mainly to low elevation snowmelt. Figure E1 (Appendix E) illustrates this hydrograph segment together with the total phosphorus loading calculated for the valley bottom snowmelt runoff period. The total phosphorus load for the 30-day period from March 18 to April 16 is 182 kg. This amount is expected to derive mainly from the developed area of the valley and may be related in large part to melt runoff from livestock winter feeding and bedding areas, although no site investigations or sub-basin sampling have been carried out.

The supply of 182 kg of total phosphorus, although an elevated snowmelt yield, is still low, considering the area of the basin. Typical phosphorus export coefficients for forested basins are in the range 0.04-1.0 kg/ha annually (Dillon and Kirchner, 1975; Rast and Lee, 1983); a 0.04 kg/ha rate would produce 1992 kg for the 498 km² Homathko basin. An additional mitigating factor is the large volume of Tatlayoko Lake. By comparison with lakes in the region which are experiencing eutrophication due to phosphorus loading - for example, Williams, Chimney, Felker, and Bouchie Lakes (Stitt et al., 1979; Nagpal, 1993; Hart, 2000, 2002) - the measured Homathko phosphorus load is low and the receiving water volume is orders of magnitude greater.

It should be noted that these data are only a single season's measurements, and that considerable year-to-year variability is expected. Also, the effects of seasonally high phosphorus concentrations on river productivity and habitat have not been assessed.

4.3.2 Stream temperature variation

Figure F1 (Appendix F) shows the variation of temperature in Homathko River, Crazy Creek, and Skinner Creek through the April-October, 2006 season. In this order, the average of measured temperatures during July and August were 12.2, 10.9, and 8.6ºC and maximum temperatures recorded were 12.2, 12.9 and 9.2ºC.

The summer temperatures of 10-13°C in Homathko River warrant continued monitoring, since they're close to the 15°C threshold for bull trout (Oliver and Fidler, 2001), the most temperature-sensitive species in the river.

4.3.3 Stream pH variation

Figure G1 (Appendix G) shows the variation of pH (hydrogen ion activity) in Homathko River, Crazy Creek, and Skinner Creek water through the April-October, 2006 season. pH values were highest in Skinner Creek draining the more alkaline soils and bedrock of the Chilcotin Plateau, intermediate in Homathko River, and lowest in Crazy Creek which drains the more acidic surficial materials of the Coast Mountains. All pH values are within ranges typical of natural stream systems in these environments.

4.3.4 Suspended sediment yield

Figure H1 (Appendix H) illustrates the variation of total suspended solids concentrations in Homathko River, Crazy Creek, and Skinner Creek through the 2006 open-water season. For the snowmelt period, sediment concentrations in Homathko River are generally an order of magnitude higher than in Skinner and Crazy Creeks. The higher downstream sediment concentrations are thought to be related primarily to land use effects in the valley on both surface erosion rates and on the stability of the mainstem alluvial channel.

Figures H2 to H4 show the suspended sediment yields at the three monitoring stations and Table 3 presents the calculated quantities for distinct periods. In all cases the higher flows of the snowmelt periods produced the highest yields, with Homathko River loads being an order of magnitude higher than Crazy Creek and two orders higher than Skinner Creek. As noted, the monitoring period was distinguished by the lack of any significant, runoff-producing storm events.

Sediment yield is typically very low in undisturbed, forest watersheds, unless sediment is delivered to channels from mass wasting (slope instability) sources. Sediment sources have not been specifically investigated in Skinner Creek or Crazy Creek basins; however, there are significant mass wasting sites along the steep slopes adjacent to Crazy Creek, and no known unstable slopes adjacent to Skinner Creek. Additional sources are present above treeline in Crazy Creek basin: small, alpine glaciers contribute fine sediment, although the numerous small lakes would act as sediment sinks; and exposed alpine soils may deliver sediment to channels. In Skinner Creek basin, the principal, natural sediment sources would be related to fluvial erosion along the main channel and its tributaries. The probable minor contributions of logging and roads have not been investigated.

Table 3. Dissolved and suspended solids yields.

Stream	Period	Solids yield (tonnes)		
		TSS	TDS	Total
Homathko River	18 Mar-12 May	69.0	374	443
	13 May-6 Jul	175	914	1089
	7 Jul-22 Oct	18.5	626	645
	Total	263	1914	2177
Crazy Creek	29 Mar-9 May	0.348	25.7	26.0
	10 May-6 Jul	20.9	263	284
	7 Jul-22 Oct	1.73	313	315
	Total	23.0	601	624
Skinner Creek	30 Mar-6 Jul	2.58	43.0	45.6
	7 Jul-22 Oct	0.357	9.37	9.73
	Total	2.94	52.4	55.3

In the varied terrain of the Homathko basin, slope and channel sediment sources such as those noted would be activated with varying frequencies and would have differing magnitudes of response. For example, Crazy Creek sediment yields may be low in most years, but then be very

high in response to high magnitude rain or rain-on-snow events which cause slope failures. On the other hand, sediment supply along the Homathko River mainstem may be consistently higher during smaller events, with yields during large floods accounting for a smaller proportion of total yield. To interpret land use impacts on stream sedimentation it is therefore critical that water monitoring is designed to identify the relative importance of hydrologic and geomorphic events through a range of magnitudes and event types, particularly those generated by storms. Due to logistical difficulties there are often limited storm runoff data in long-term monitoring records.

4.3.5 Turbidity

In-stream turbidity measurements can be used to predict suspended sediment concentrations; however, for the low concentrations during the study period no strong relationships were defined. As Figure I1 (Appendix I) shows, there is considerable scatter of points as the resolution of the instrument and the accuracy of the lab analysis of TSS is approached. Turbidity-suspended sediment relationships would be usefully applied to higher TSS concentrations, notably for monitoring stormflow and high snowmelt discharge periods.

4.3.6 Dissolved sediment yield

The pattern of watershed dissolved solids concentrations varies predictably with basin geology. Skinner Creek, underlain by volcanic rock and alkaline soils, exhibits the highest dissolved solids concentrations; and Crazy Creek, draining Coast Mountain terrain underlain by less soluble plutonic bedrock, has significantly lower dissolved solids concentrations. Homathko River solute concentrations are intermediate between the two (Figure J1, Appendix J). The total dissolved solids yields listed in Table 3 are dominated by discharge, with Homathko River yields being greatest, followed by Crazy Creek, and then Skinner Creek.

4.3.7 Conductivity

For predictive purposes the ratio of specific conductance to dissolved solids concentration (residue on evaporation) can be calculated for individual streams. These ratios are typically in the range 0.55 to 0.75 (Hem, 1970) and are often approximated by use of the ratio 0.65. For this season's sampling the following ratios were determined:

Stream	**SC/TDS ratio**
Homathko River	0.61
Crazy Creek	0.69
Skinner Creek	0.57

These ratios could be used to provide an estimate of solute concentration in the absence of lab analysis; however, considerable scatter was found in the relationship between the two variables (e.g., Figure K1, Appendix K). Instrument malfunction is being examined as a possible source of the variability.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A network of stations in the Homathko River basin has been established to enable monitoring of climate, streamflow, and water quality. Monitoring data will identify trends related to changing climate, land and water uses, and restoration measures. The data will also provide a basis for further scientific studies, such as modeling of hydrometeorologic variation across the watershed and investigations of habitat suitability for fish.

To provide a local capability for water quality research and related studies, a laboratory was established in the basin for analysis of suspended and dissolved solids concentrations in water. For a one-month period during the low-elevation snowmelt runoff, Homathko River samples were analyzed by a commercial lab for total phosphorus, total suspended solids, and total dissolved solids. All subsequent analyses were conducted in the local, project lab.

The principal objectives of this study were to establish a hydrometric and water quality monitoring network, to establish a local lab for water analysis and related studies, and, in a final report, to describe the study area and to report the season's research results. At this stage, no detailed analyses of the available climatic, hydrologic, or land and water use data are carried out.

Summarizing this year's principal monitoring observations:

- snow water equivalent preceding snowmelt at the Ministry of Environment high-elevation automated stations was 85 to 90% of normal;
- the March to October flow monitoring period was particularly dry, with no rainstorms occurring which produced significant storm runoff events;
- Homathko River total phosphorus load for the 30-day, low-elevation snowmelt period was determined to be 182 kg, an amount which may be related in large part to melt runoff from livestock winter feeding and bedding areas;
- Homathko River stream temperatures were in the range 10-13°C during July and August, temperatures approaching the 15°C threshold for bull trout, the most temperature-sensitive species in the river; and
- Homathko River suspended and dissolved sediment concentrations and yields exceeded those of Crazy Creek and Skinner Creek by at least an order of magnitude.

With respect to Nature Conservancy of Canada research and stewardship interests in the Homathko basin, the following recommendations for further study are put forward for consideration:

- continue baseline monitoring of snow accumulation, rainfall, streamflow, and water quality;
- establish a permanent flow gauging station on Lincoln Creek at NCC's Lincoln Creek Ranch and sample water quality just upstream of the ranch;
- monitor flow and water quality at two additional stations along Homathko River upstream of the existing station;
- monitor stormflow water quality and quantity at selected stations with a focus on variation of suspended sediment yield;

- assess whether flows in known fish streams tributary to Homathko River meet minimum requirements for fish by carrying out summer baseflow measurements and evaluating licensed water withdrawals; and
- assess in-stream habitat conditions for fish, including stream temperature regime, stream sedimentation, bed material characteristics, and riparian vegetation condition.

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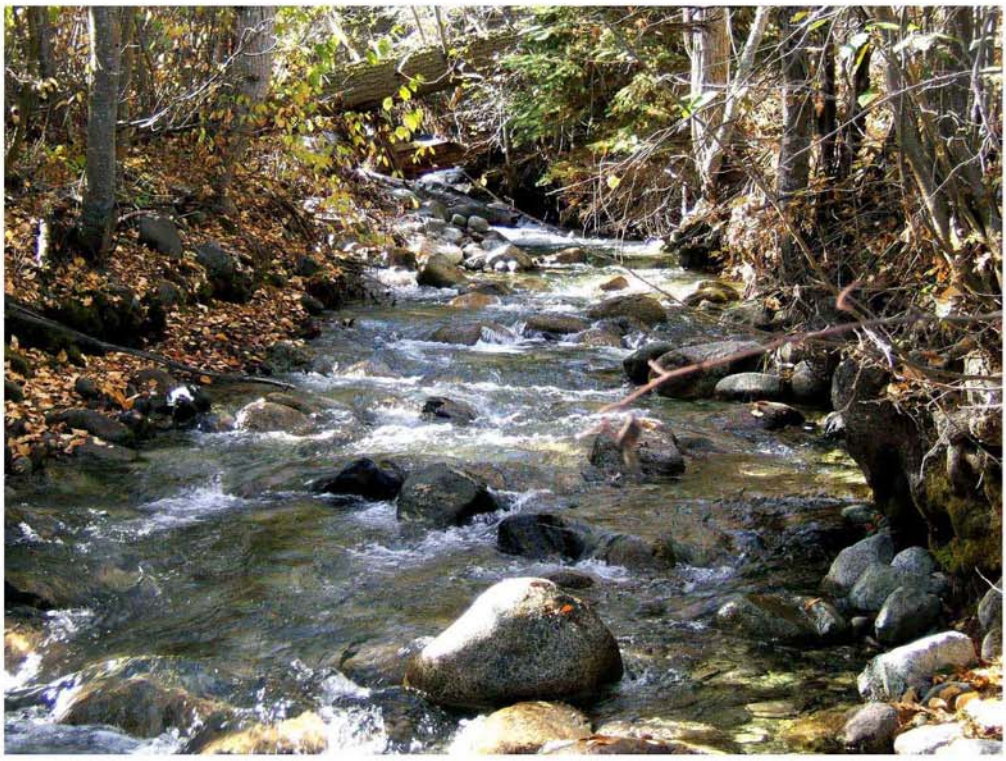
Photograph 1. Homathko River at sampling station, May 2006.

Photograph 2. Homathko River at sampling station, October 2006.



Photograph 3. Crazy Creek upstream of gauging station, October 2006.

Photograph 4. Skinner Creek upstream of gauging station, October 2006.

APPENDIX A. GAUGING STATION BENCHMARKS AND REFERENCE POINTS.

Table A1. Crazy Creek benchmark survey, 3 August 2006.

Reference stadia readings (m):

Spike on hydro pole to north, west side of road	**3.662**
Spike at base of fir tree to southwest beside road	**0.654**
S5 stage benchmark	**1.278**
S4 stage benchmark	**1.281**

Table A2. Skinner culvert gradient survey, 30 August 2006.

In-culvert depth	**0.033 m**
Stage	**1.307 m**
Culvert diameter	**1380 mm**
Culvert roughness (n)	**0.023**
Culvert slope (upstream end of first ring, culvert depth site)	**0.034**

APPENDIX B. LAB PROCEDURES FOR SUSPENDED AND DISSOLVED SOLIDS ANALYSIS.

TABLE B1. LABORATORY PROCEDURE FOR ANALYSIS OF TOTAL SUSPENDED SOLIDS (NONFILTERABLE RESIDUE)

Introduction:

In this analysis the total suspended solids (TSS) fraction is determined as the particulate mineral and organic material retained by a filter of 0.45 µm pore size.

Apparatus:

- 0.45 µm pore size, 87 mm diameter filter paper
- 100 ml porcelain Buchner funnel with rubber stopper
- 1000 ml glass filter flask
- Nalgene 36 cc hand vacuum pump with gauge
- 1000 ml graduated cylinder
- aluminum sample pans
- Acculab ALC 210.4 balance (0.1 mg resolution)
- Fisher Scientific 3511FS gravity convection drying oven
- 0-250°C oven thermometer
- Nalgene 140 mm desiccator chambers with indicating desiccant
- reagent grade distilled water

Method:

A 0.45 µm filter paper is dried on an aluminum sample pan in the lab oven at 103-105°C for at least one hour. The filter and pan are cooled to ambient temperature in the desiccator, weighed, and the filter then placed in the Buchner funnel/filter flask filtration apparatus. Suction is applied to the filter by a hand-held vacuum pump as the filter is rinsed with 60 ml of reagent-grade distilled water in successive 20 ml applications; the filtrate is then discarded. The (approximately 1000 ml) sample volume is measured in a graduated cylinder then drawn through the filter. Upon completion of sample filtration, the filter is rinsed with a final 60 ml of distilled water in successive 20 ml applications. The filter is dried at 103-105°C on the aluminum pan for at least one hour, cooled to ambient temperature in the desiccator, and then weighed to calculate suspended solid quantity. The filtrate in the filter flask is used for total dissolved solids (filterable residue) analysis.

Accuracy:

Standard Methods reports studies by two analysts which determined a 5.2 mg/L standard deviation at 15 mg/L and 24 mg/L at 242 mg/L, as well as an analysis demonstrating a standard deviation of differences of 2.8 mg/L.

TABLE B2. LABORATORY PROCEDURE FOR ANALYSIS OF TOTAL DISSOLVED SOLIDS (FILTERABLE RESIDUE)

Introduction:

In this analysis the total dissolved solids (TDS) fraction is determined as the mineral and organic solute which will pass through a filter of 0.45 µm pore size.

Apparatus:

- 0.45 µm pore size, 87 mm diameter filter paper
- 100 ml porcelain Buchner funnel with rubber stopper
- 1000 ml glass filter flask
- Nalgene 36 cc hand vacuum pump with gauge
- 1000 ml graduated cylinder
- Acculab ALC 210.4 balance (0.1 mg resolution)
- Fisher Scientific 3511FS gravity convection drying oven
- 0-250°C oven thermometer
- 100 ml porcelain evaporating dishes
- Scholar PC171 magnetic stirrer
- Nalgene 140 mm desiccator chambers with indicating desiccant
- reagent grade distilled water
- 100 ml glass pipette

Method:

A 100 ml porcelain evaporating dish is heated in the drying oven at 180°C for one hour, cooled to ambient temperature in a desiccator, and then weighed. A 0.45 µm filter paper is placed in the Buchner funnel/filter flask filtration apparatus; the filter is rinsed with 60 ml of reagent-grade distilled water in successive 20 ml applications; suction is applied by a hand-held vacuum pump; and the distilled water filtrate in the filter flask is then discarded. The (approximately 1000 ml) sample volume is measured in a graduated cylinder then drawn through the filter. Upon completion of sample filtration, the filter is rinsed with a final 60 ml of distilled water in successive 20 ml applications. While in the filter flask the filtrate is well stirred by magnetic stirrer while a 100 ml volume is withdrawn by pipette and transferred to the evaporating dish. The 100 ml volume is evaporated in a drying oven and the dish is then heated at 180°C for one hour. The dish is cooled to ambient temperature in a desiccator and then weighed. The dish weight increase is used to calculate the total dissolved solids concentration in the sample.

Accuracy:

Standard Methods reports one study which determined a standard deviation of differences of 21.2 mg/L for 77 samples of a known 293 mg/L concentration.

Lab procedure references:

British Columbia Environmental Laboratory Manual. 2005. Water and Air Monitoring and Reporting Section. Ministry of Environment, British Columbia.

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APPENDIX C. STAGE-DISCHARGE RATING CURVES.

Figure C1. Crazy Creek stage-discharge rating curve, 2006.

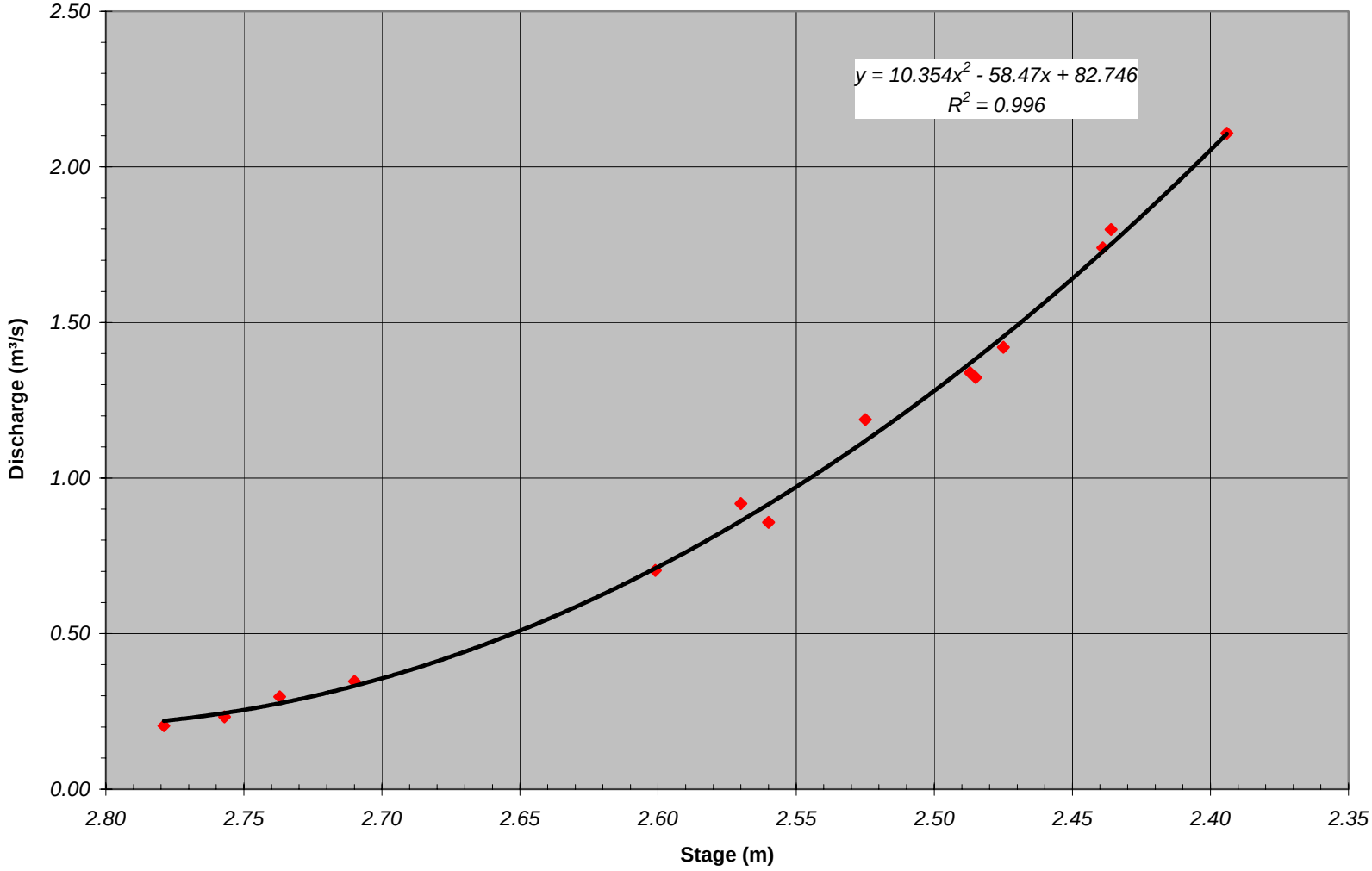
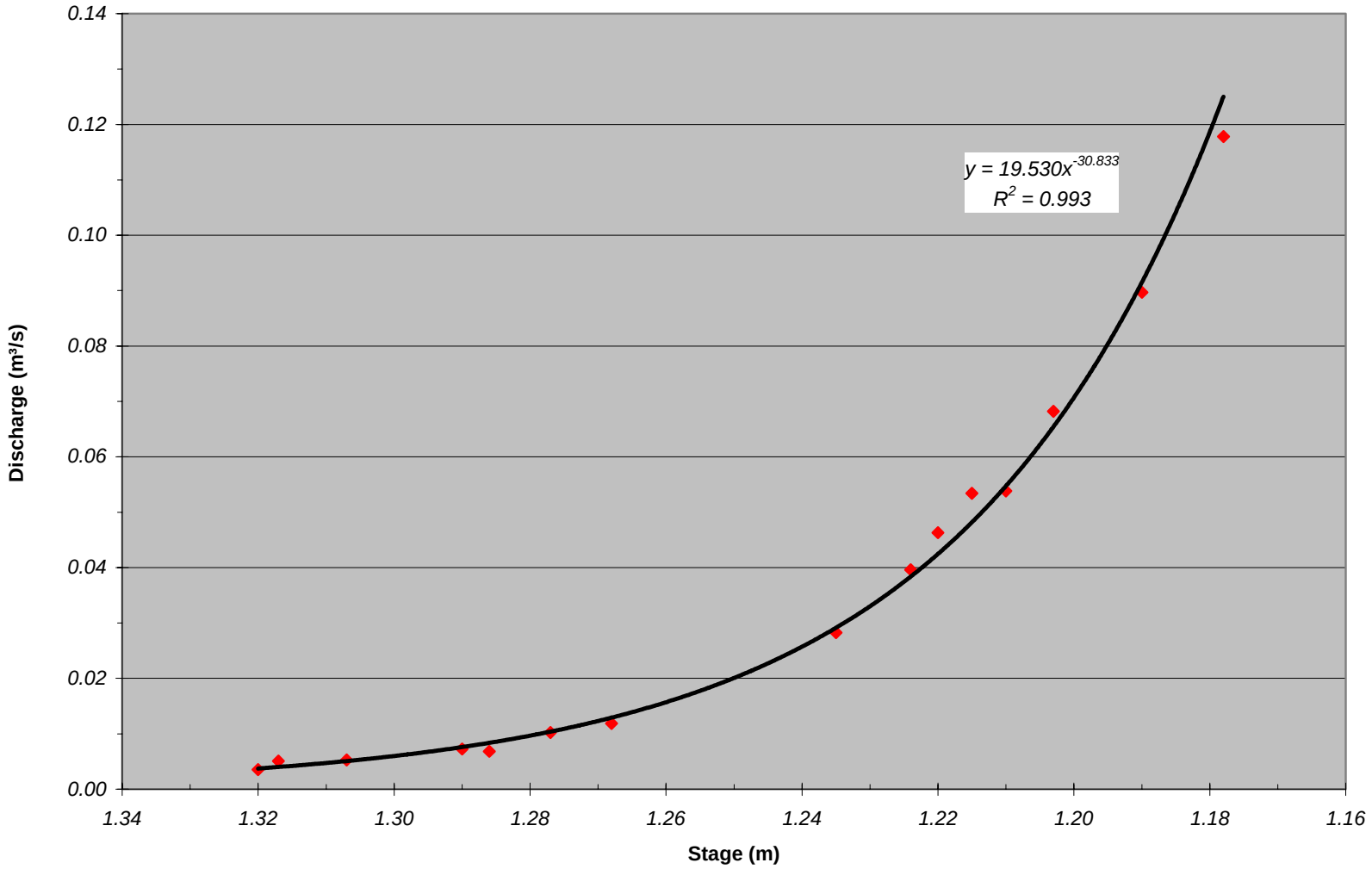


Figure C2. Skinner Creek stage-discharge rating curve, 2006.



APPENDIX D. HYDROGRAPHS.

Figure D1. Homathko River hydrograph, 2006.
(Preliminary data from Water Survey of Canada Station 08GD008)

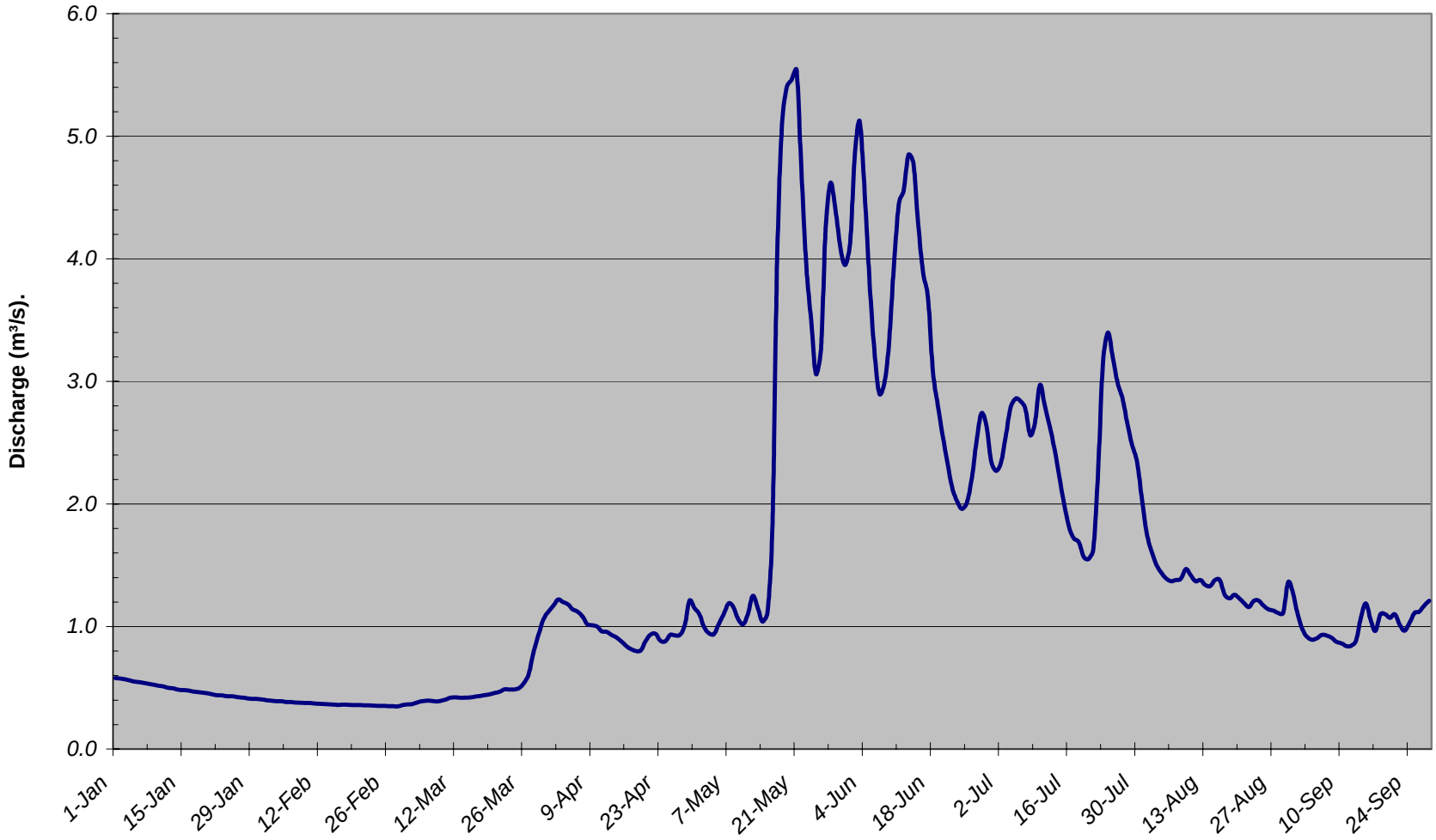


Figure D2. Crazy Creek hydrograph, 2006.

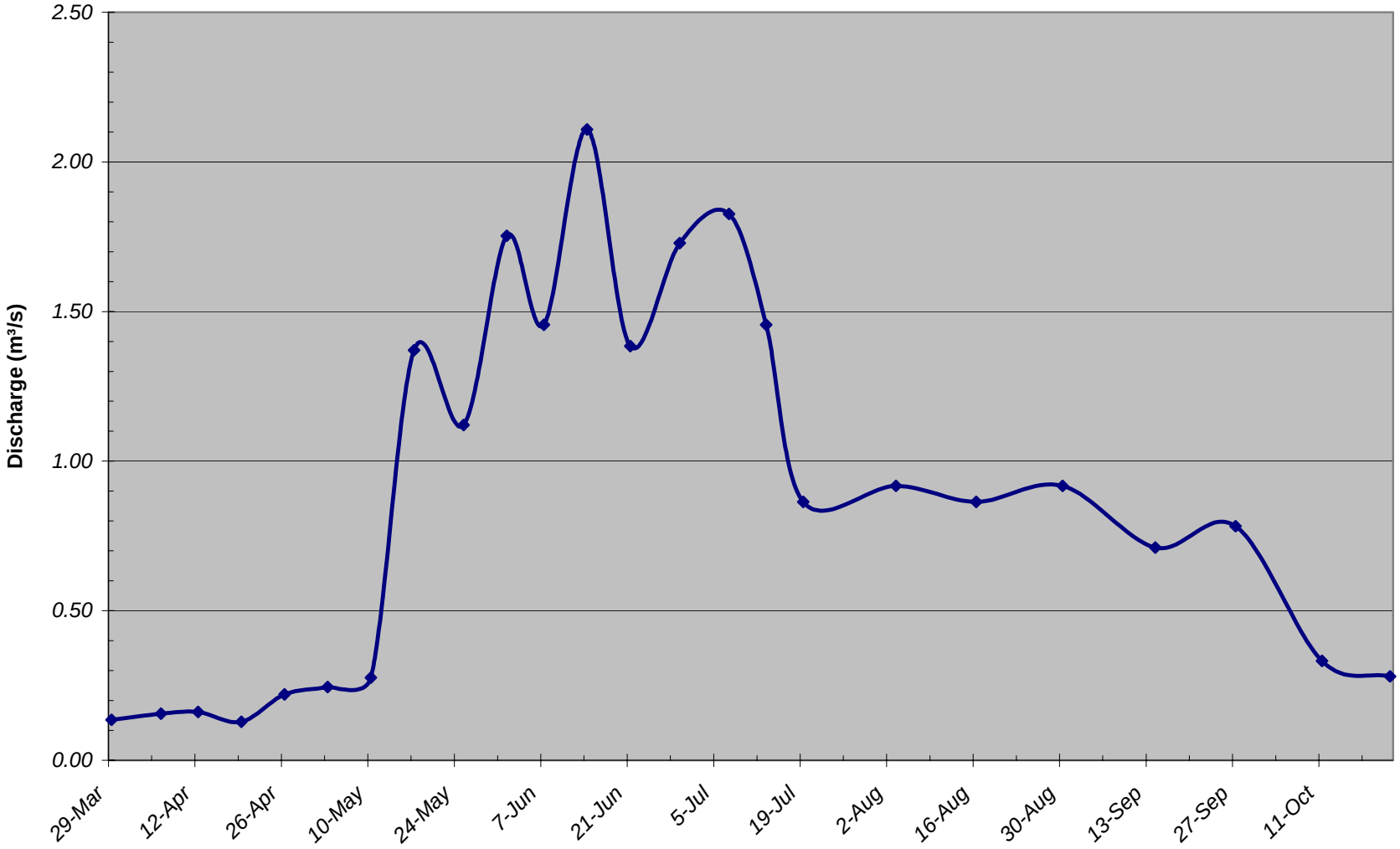
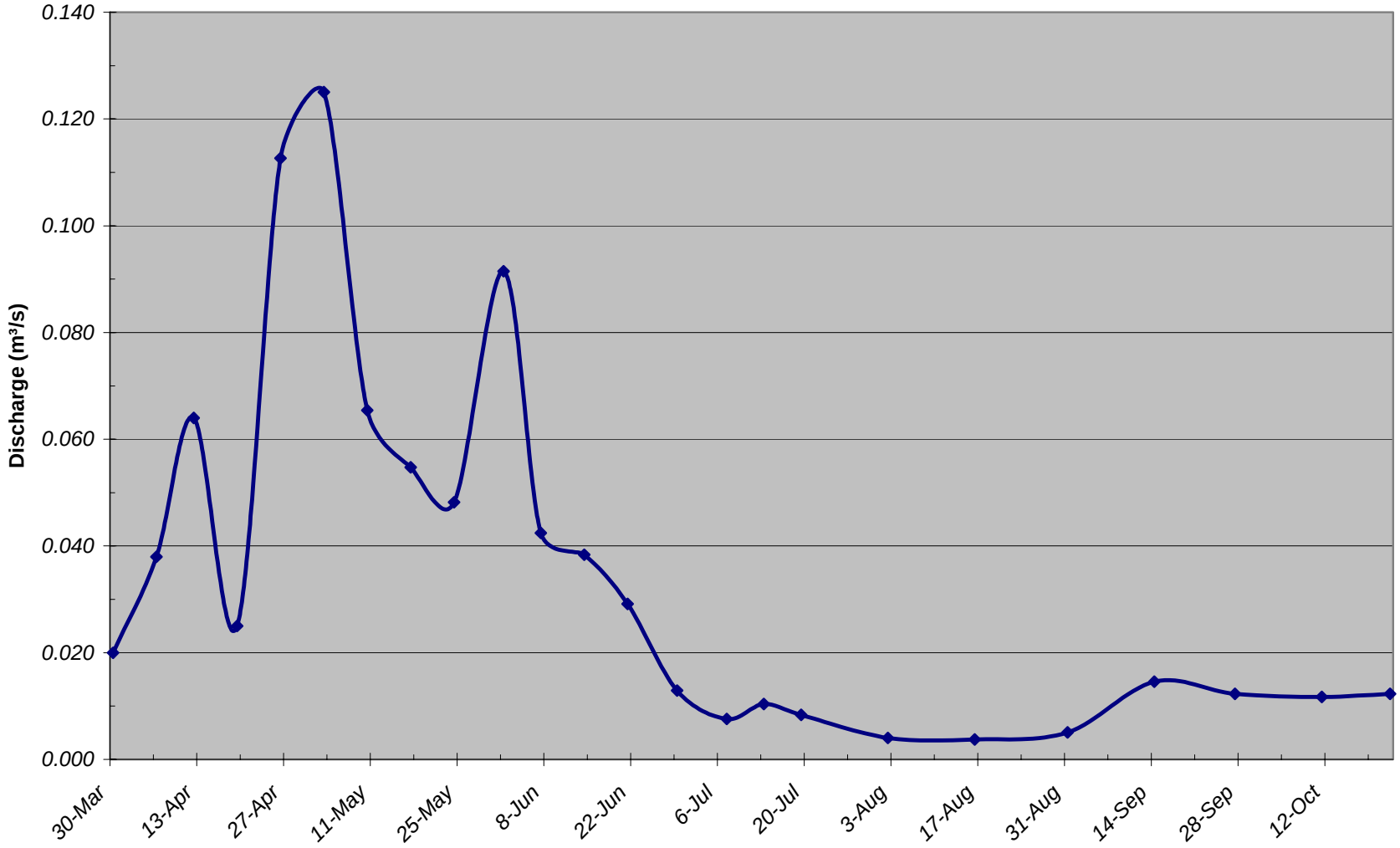
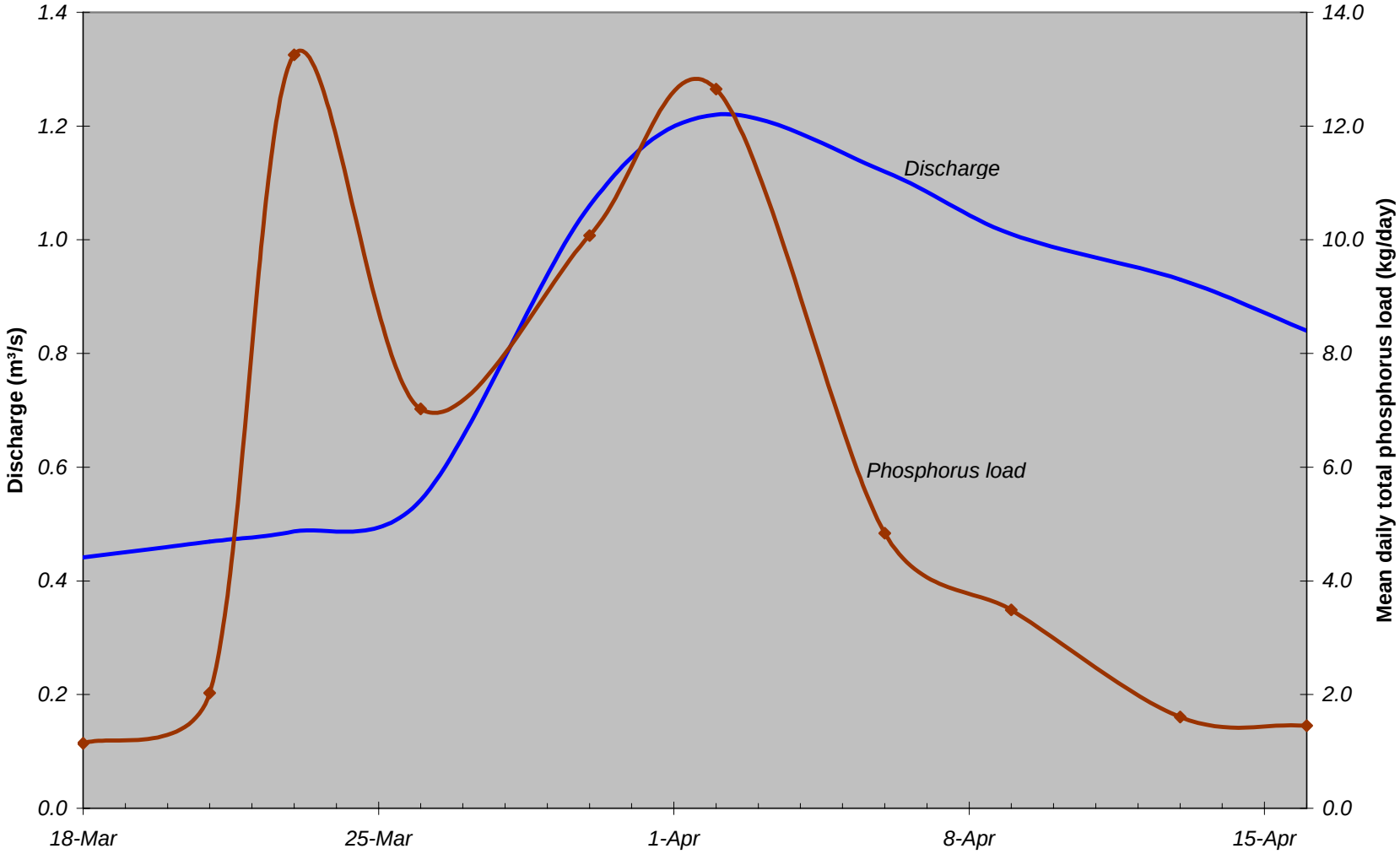


Figure D3. Skinner Creek hydrograph, 2006.



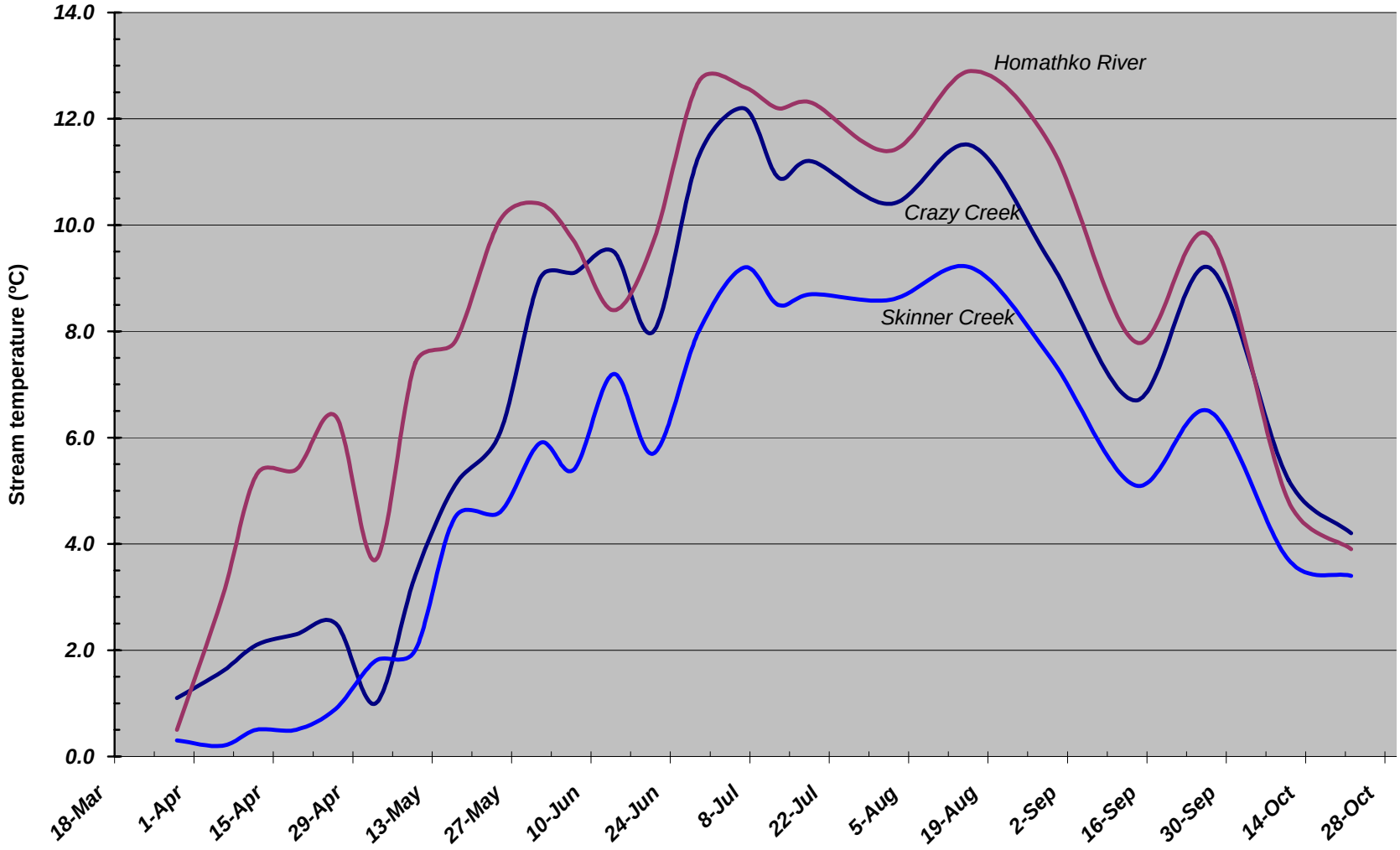
APPENDIX E. HOMATHKO RIVER SNOWMELT PERIOD PHOSPHORUS YIELD.

Figure E1. Homathko River early snowmelt period phosphorus load and discharge, 2006.



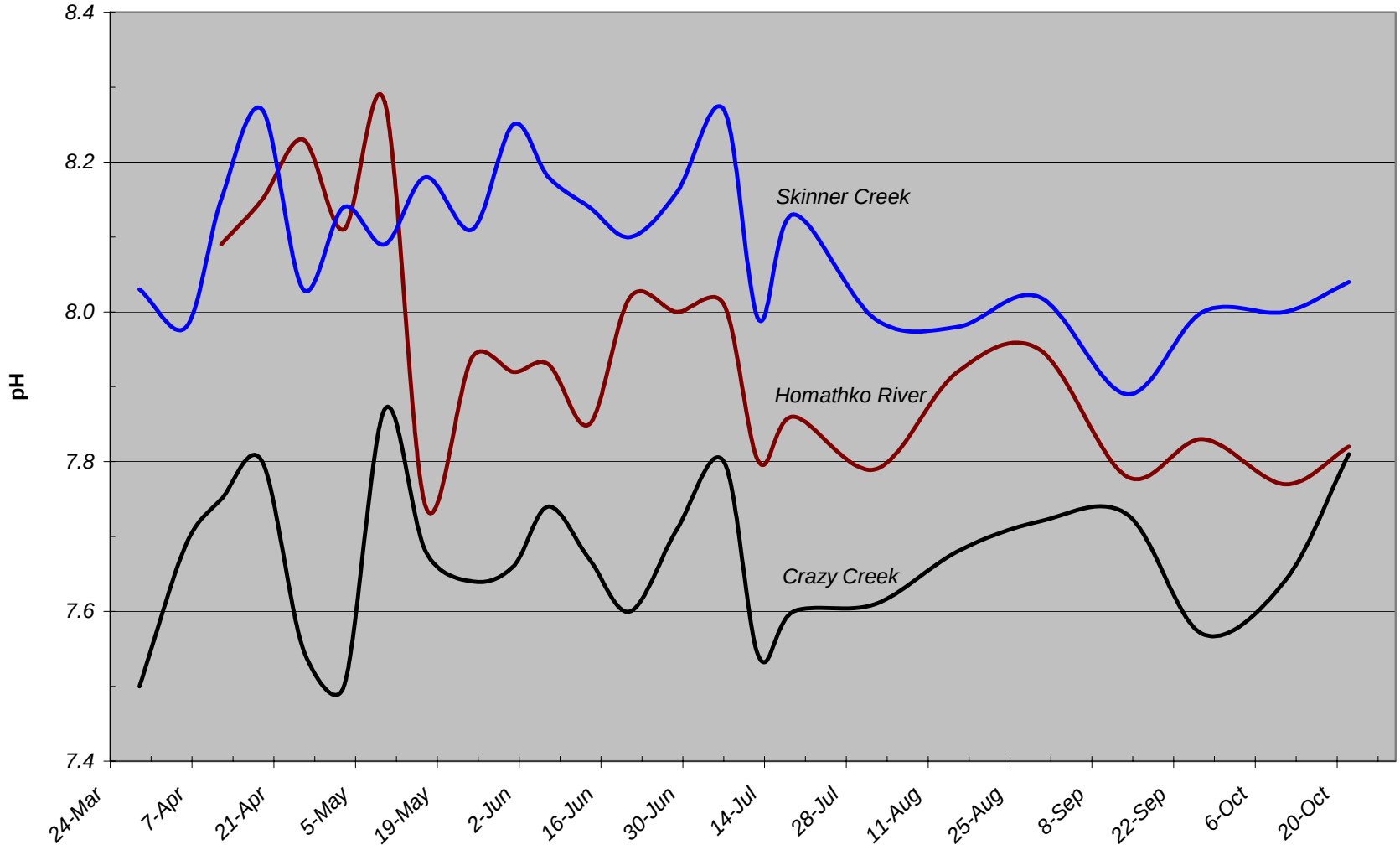
APPENDIX F. STREAM TEMPERATURE VARIATION.

Figure F1. Temperature variation in Homathko River, Crazy Creek, and Skinner Creek, 2006.



APPENDIX G. STREAM pH VARIATION.

Figure G1. pH variation in Homathko River, Crazy Creek, and Skinner Creek, 2006.



APPENDIX H. SUSPENDED SEDIMENT TRANSPORT.

Figure H1. Suspended solids concentrations of Homathko basin watercourses, 2006.

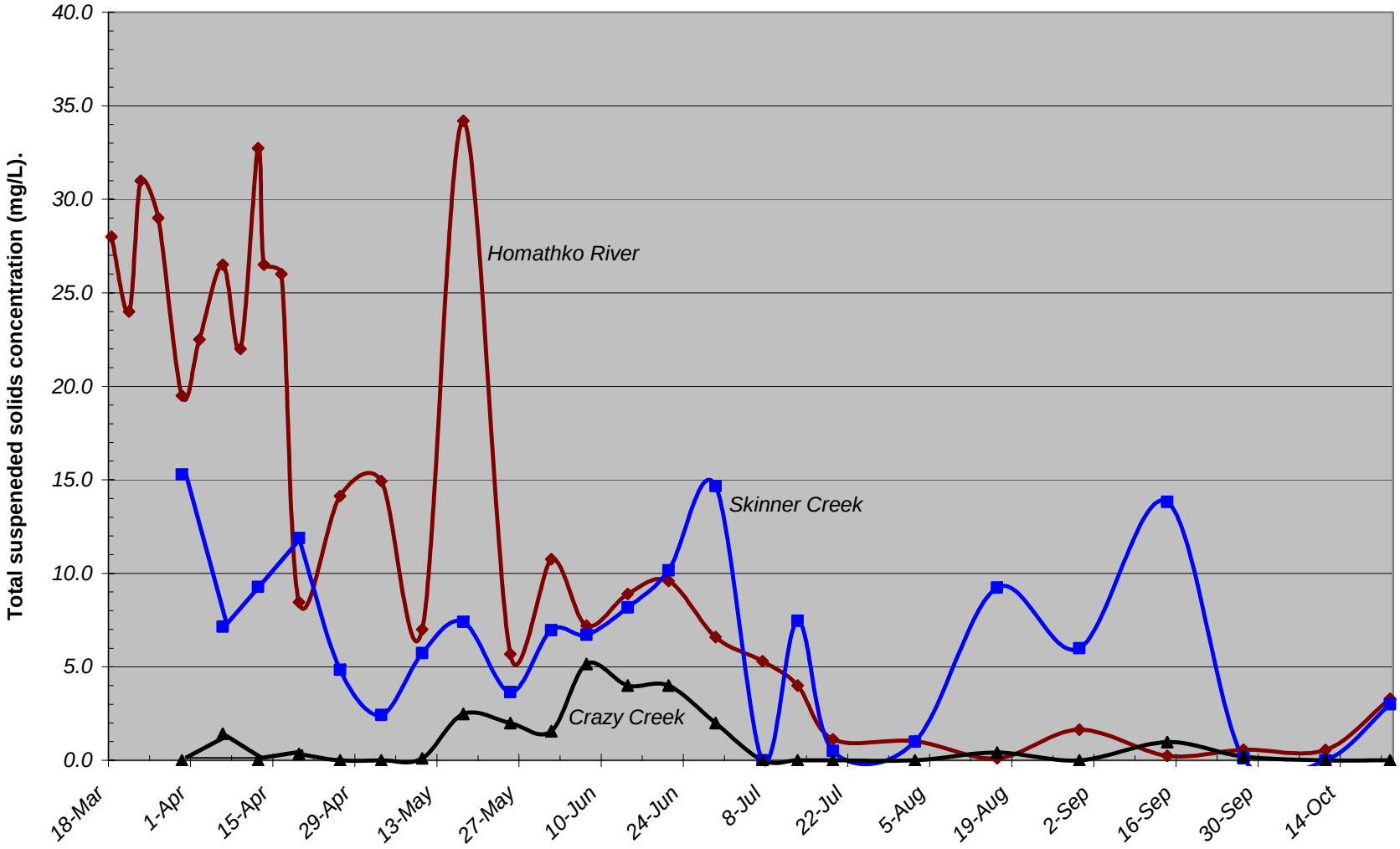


Figure H2. Homathko River suspended solids load, 2006.

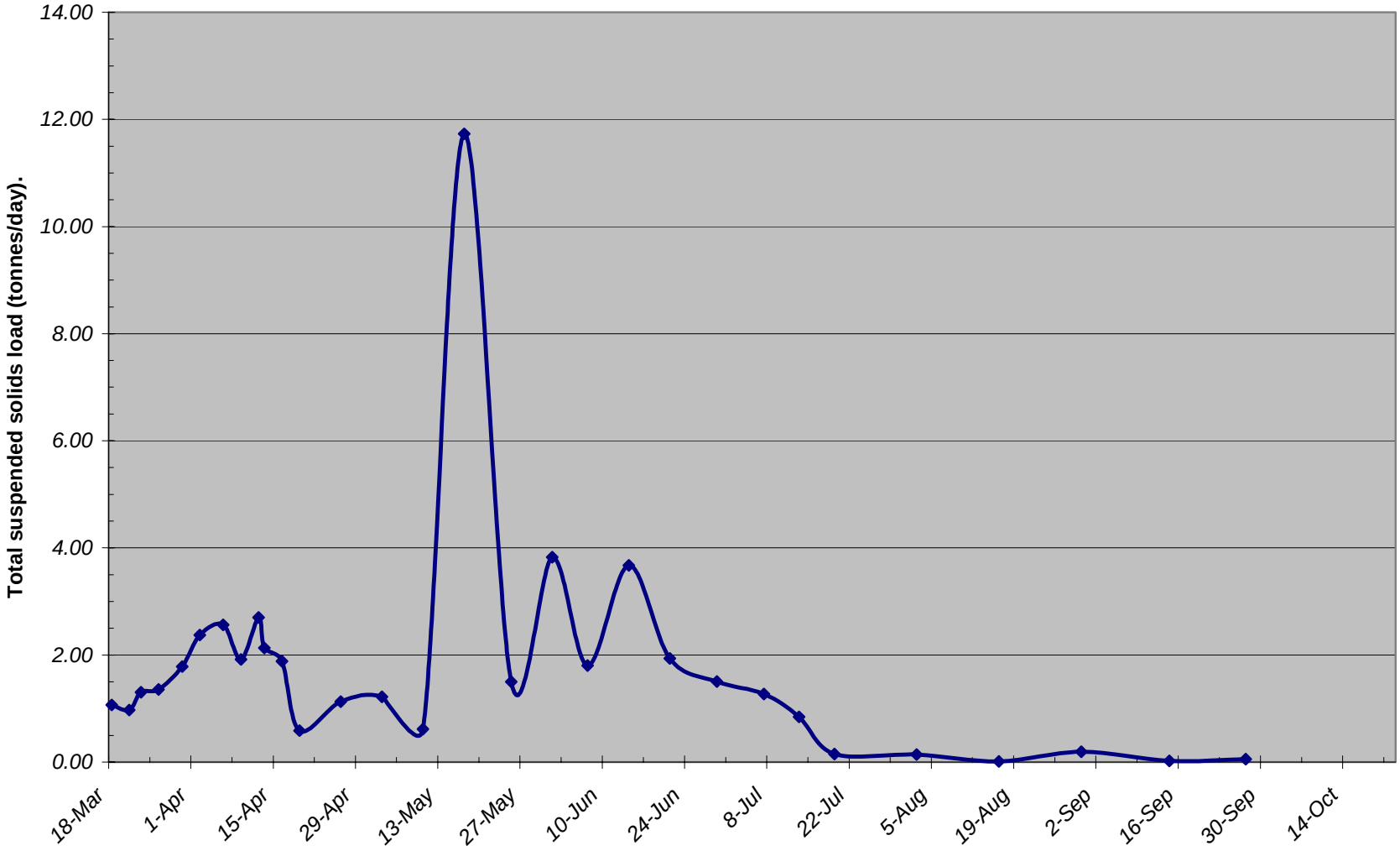


Figure H3. Crazy Creek suspended solids load, 2006.

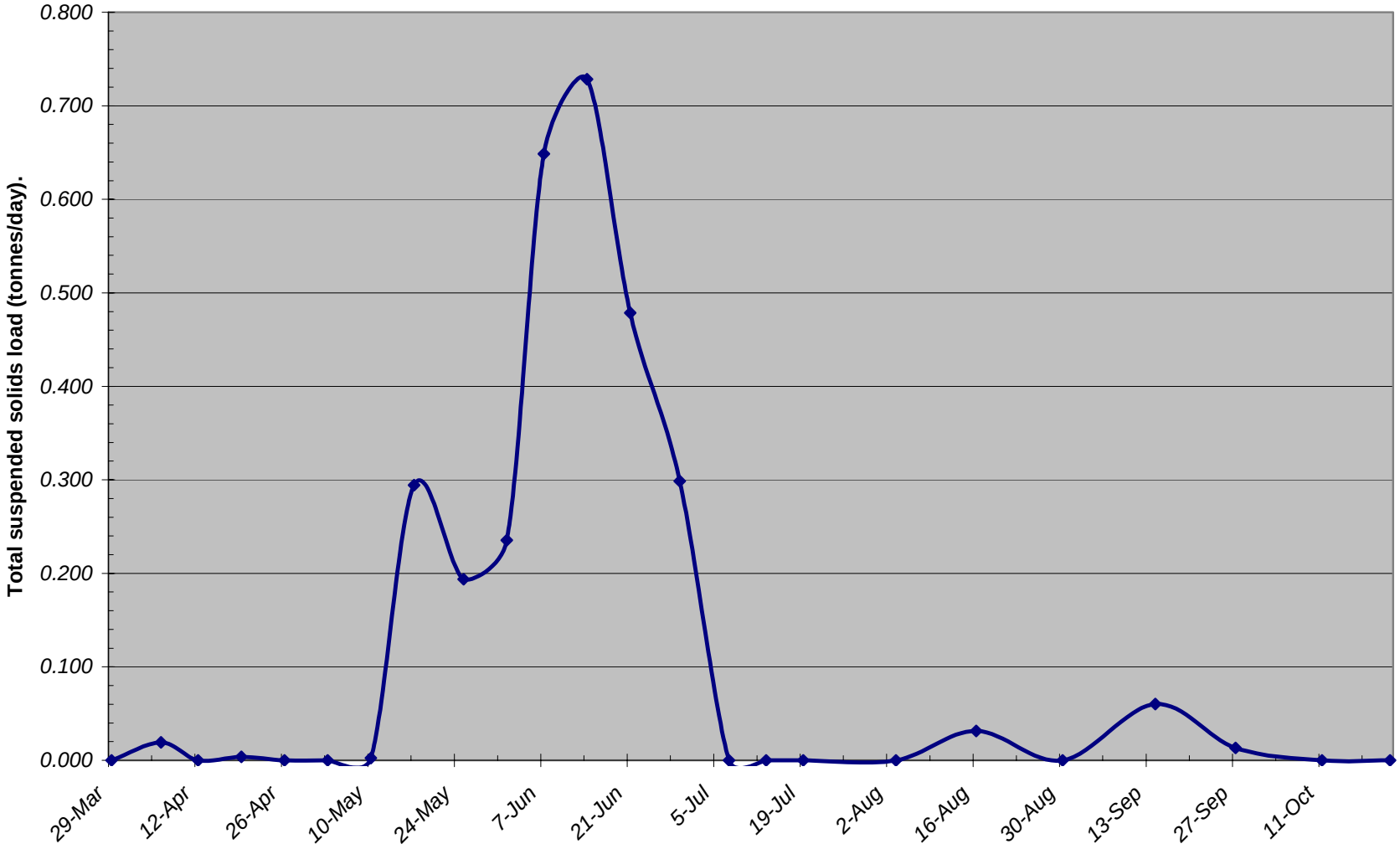
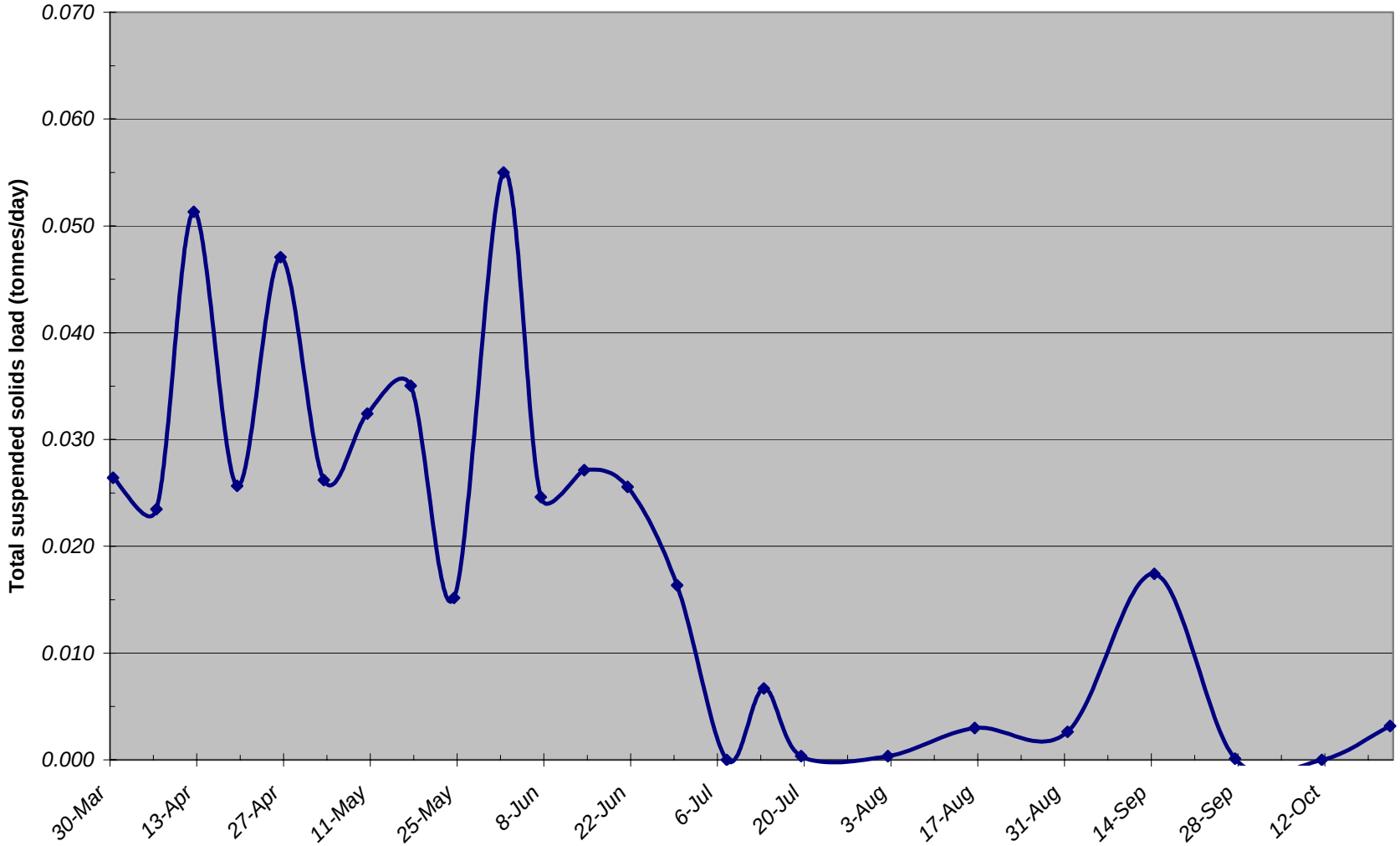
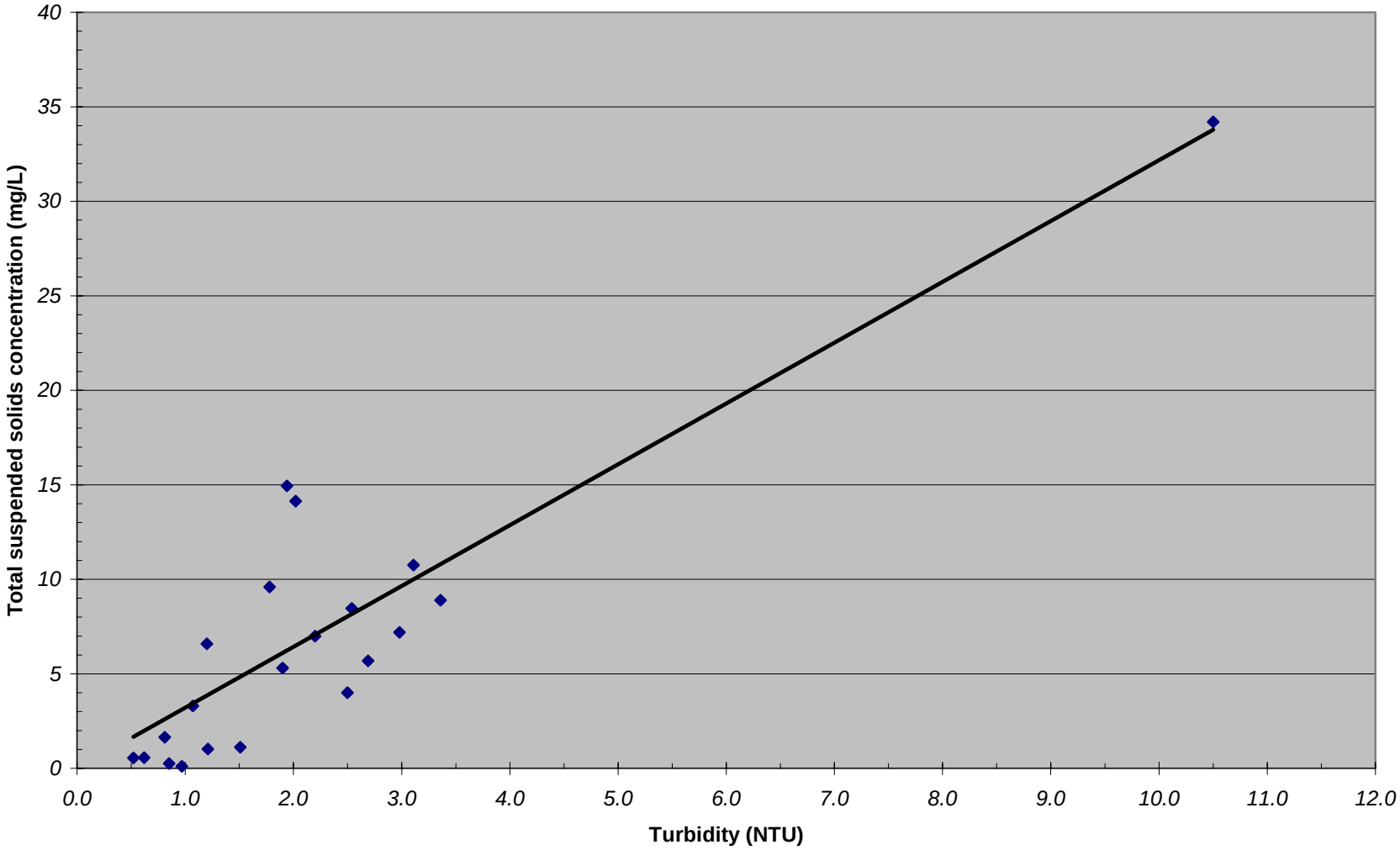


Figure H4. Skinner Creek suspended solids load, 2006.



APPENDIX I. HOMATHKO RIVER TURBIDITY-SUSPENDED SOLIDS RELATIONSHIP.

Figure I1. Homathko River turbidity-suspended solids relationship, 2006.



APPENDIX J. DISSOLVED SEDIMENT TRANSPORT.

Figure J1. Dissolved solids concentrations of Homathko basin watercourses, 2006.

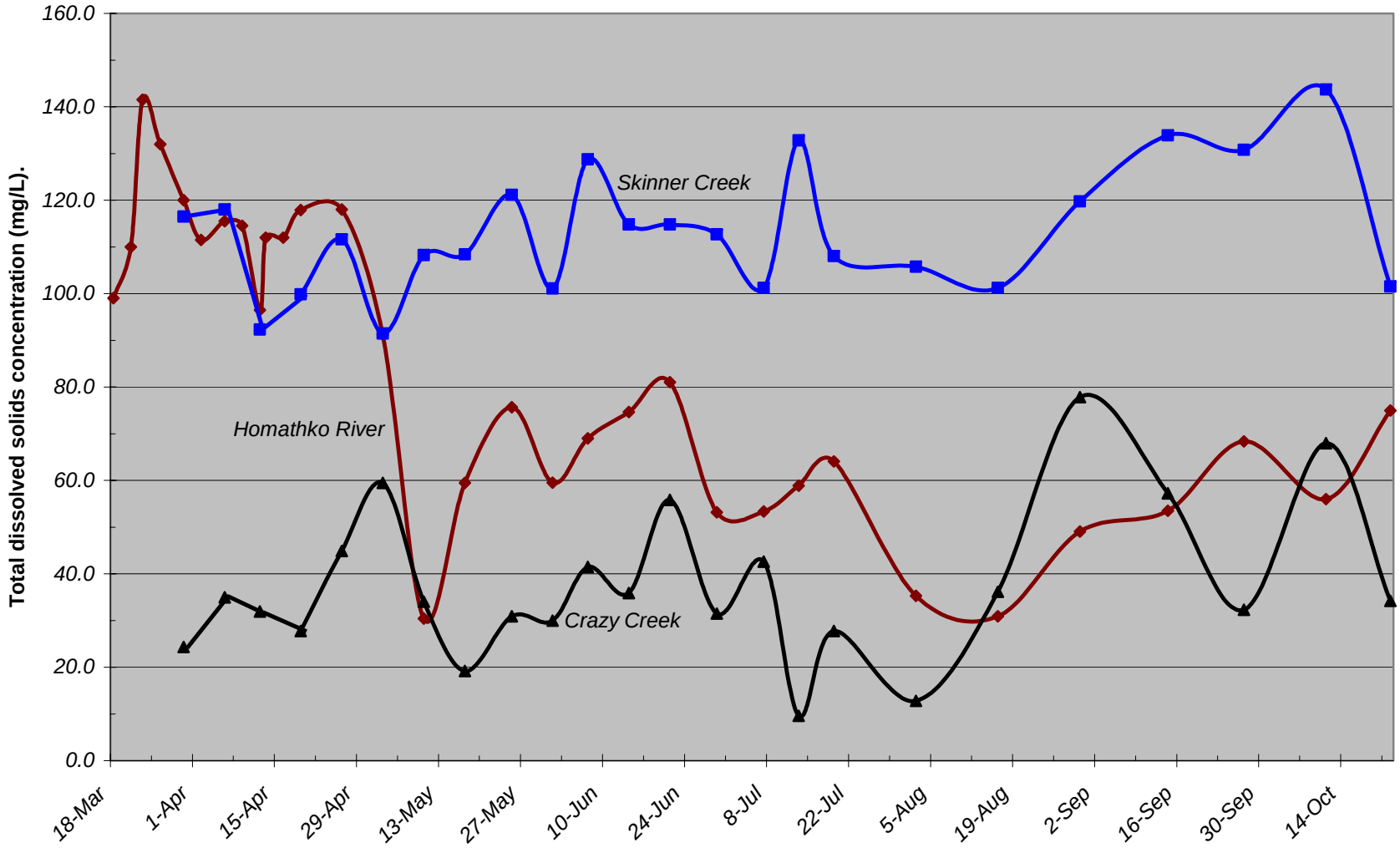


Figure J2. Homathko River dissolved solids load, 2006.

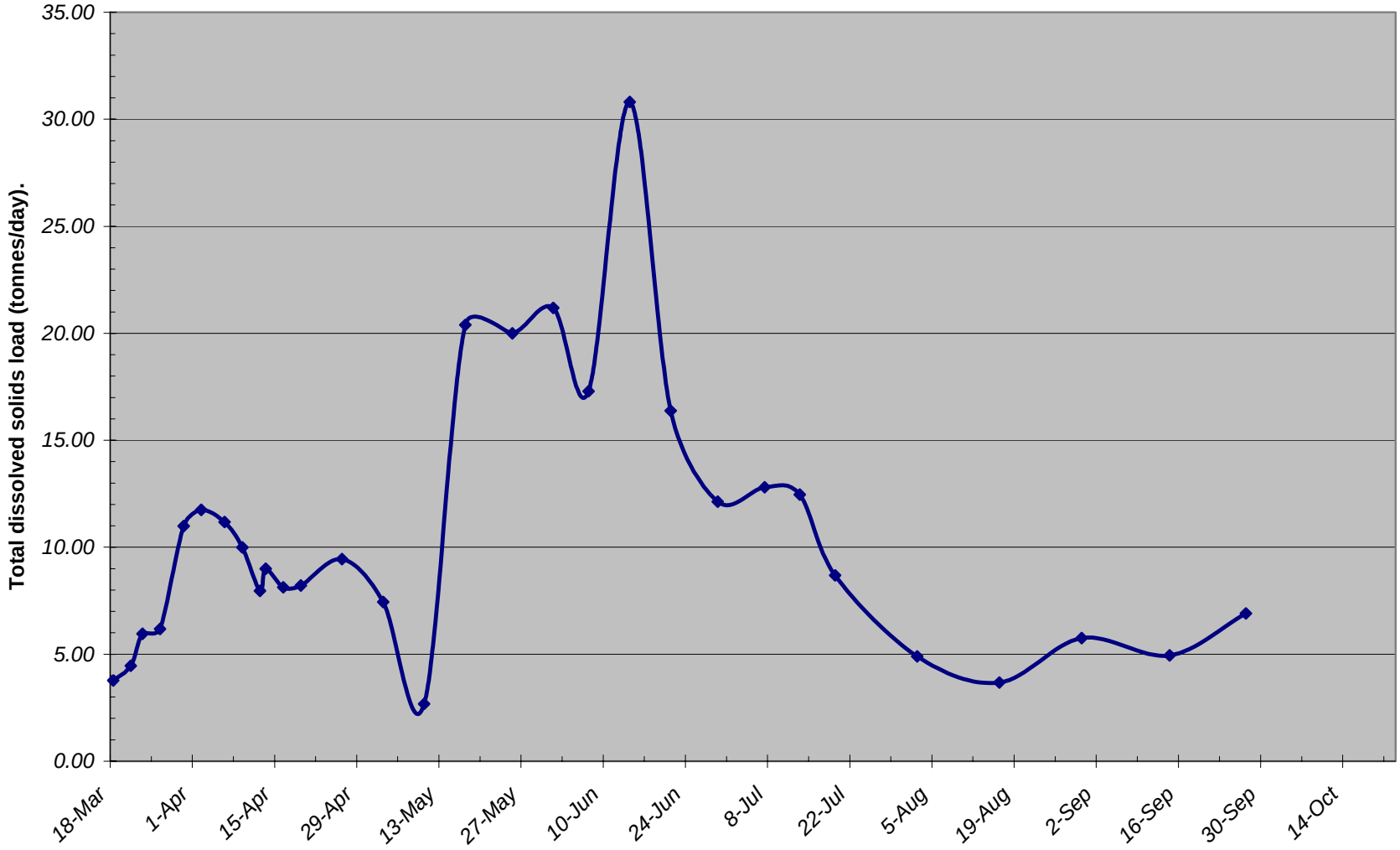


Figure J3. Crazy Creek dissolved solids load, 2006.

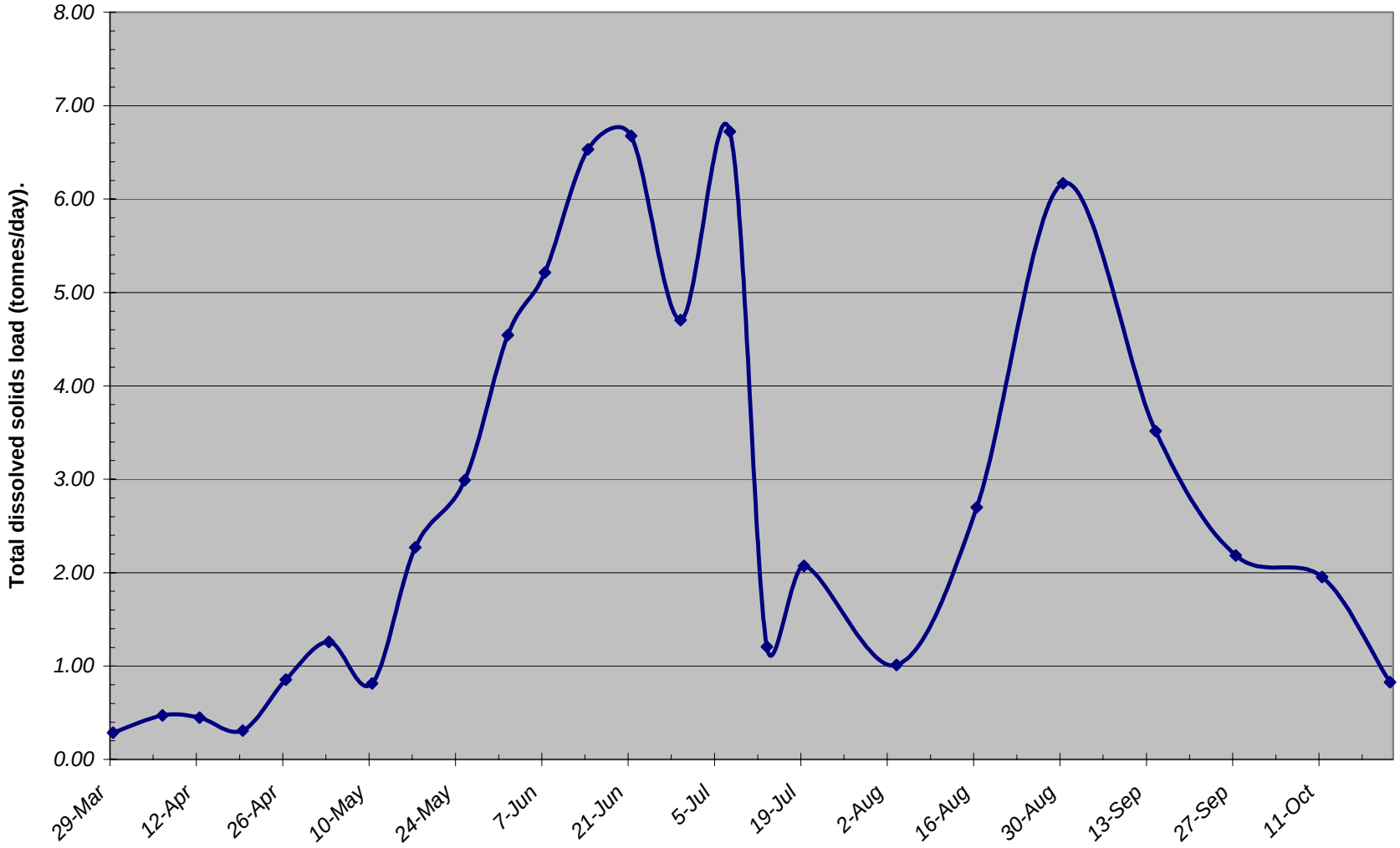
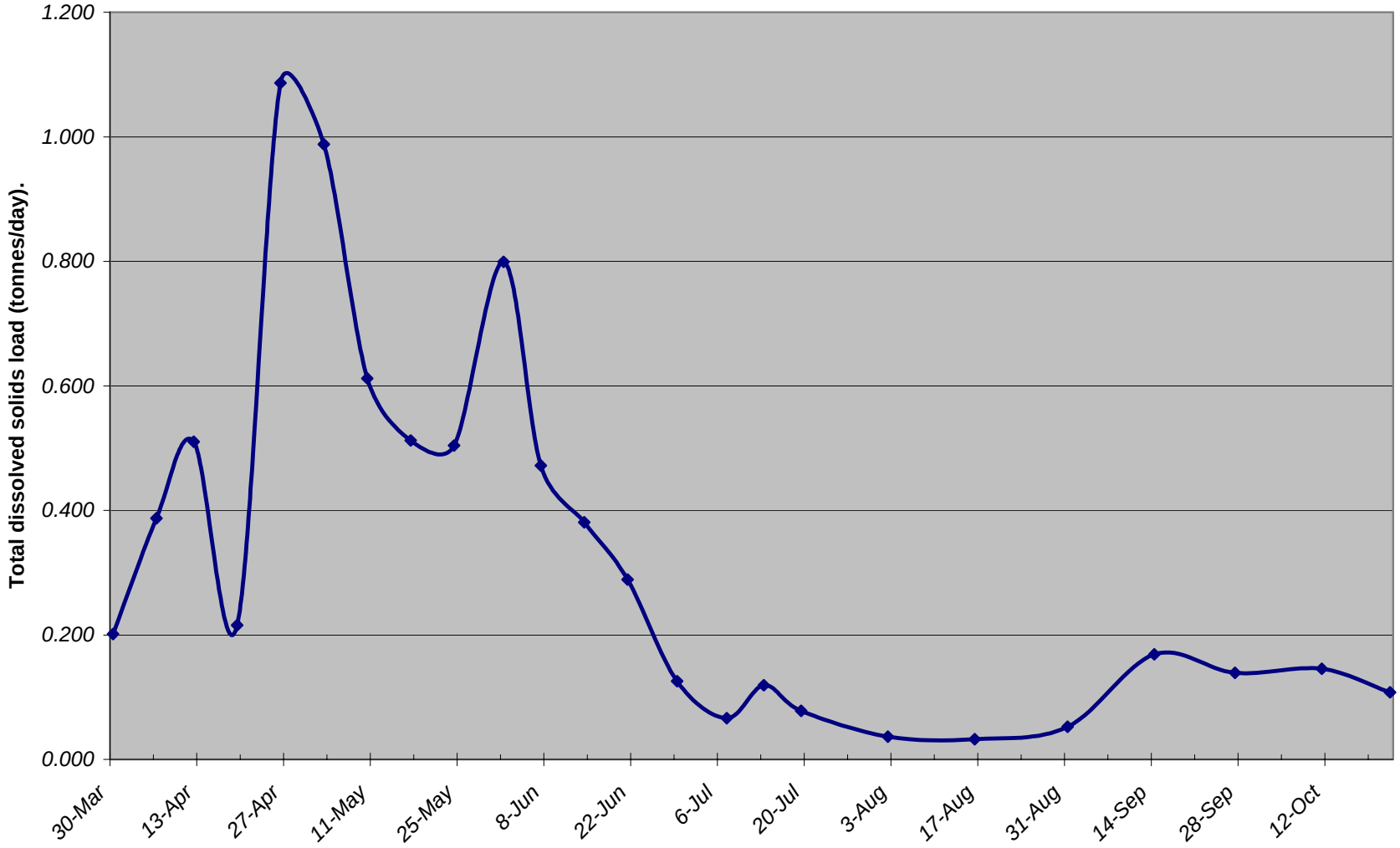
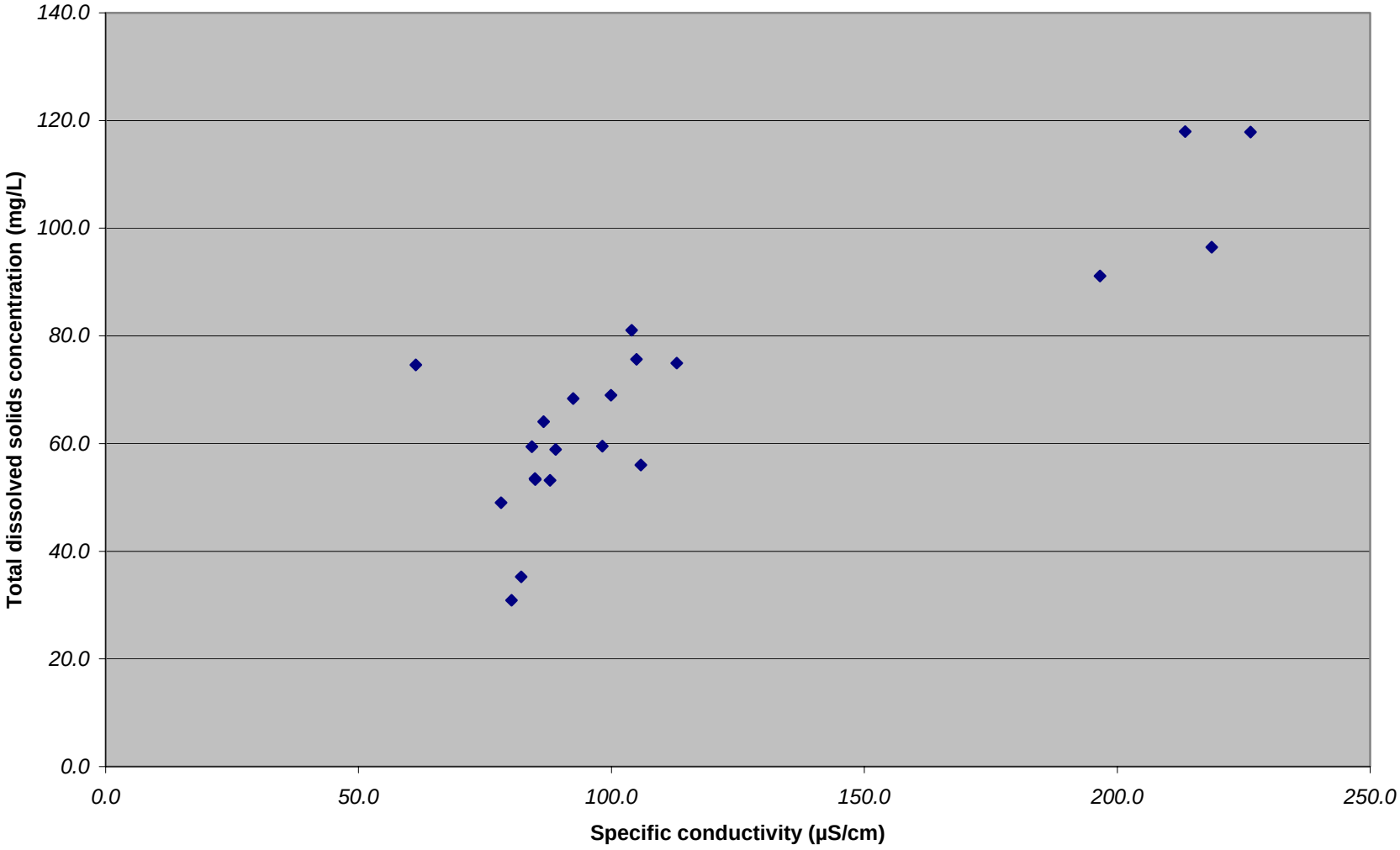


Figure J4. Skinner Creek dissolved solids load, 2006.



APPENDIX K. HOMATHKO RIVER CONDUCTIVITY-DISSOLVED SOLIDS RELATIONSHIP.

Figure K1. Homathko River conductivity-dissolved solids relationship, 2006.



APPENDIX L. DISCHARGE AND WATER QUALITY DATA SUMMARIES.

Table L1. Homathko River discharge and water quality data, 2006.

Date	Time	Discharge (m^3/s)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Spec. cond. (µS/cm)	Temp. (°C)	pH
18-Mar		0.441	28.0	99.0					
21-Mar		0.469	24.0	110.0					
23-Mar		0.487	31.0	141.5					
26-Mar		0.542	29.0	132.0					
29-Mar	14:00	0.940				120.6	226.7	0.5	7.74
30-Mar		1.060	19.5	120.0					
2-Apr		1.220	22.5	111.5					
6-Apr		1.120	26.5	115.5					
9-Apr		1.010	22.0	114.5					
12-Apr	14:30	0.955	32.7	96.5	3.25	136.4	218.7	5.3	8.09
13-Apr		0.930	26.5	112.0					
16-Apr		0.840	26.0	112.0					
19-Apr	14:10	0.806	8.5	117.9	2.54	141.6	226.3	5.4	8.15
26-Apr	13:30	0.927	14.1	118.0	2.02	137.6	213.4	6.4	8.23
3-May	10:50	0.945	14.9	91.1	1.94	116.6	196.6	3.7	8.11
10-May	13:35	1.020	7.0	30.4	2.20	117.6	177.2	7.4	8.28
17-May	13:55	3.970	34.2	59.4	10.50	56.6	84.3	7.8	7.74
25-May	16:45	3.060	5.7	75.7	2.69	75.1	105.0	10.1	7.94
1-Jun	13:20	4.120	10.8	59.5	3.11	70.8	98.2	10.4	7.92
7-Jun	12:10	2.900	7.2	69.0	2.98	70.7	99.9	9.7	7.93
14-Jun	12:05	4.780	8.9	74.6	3.36	41.9	61.4	8.4	7.85
21-Jun	13:10	2.340	9.6	81.0	1.78	73.6	104.0	9.7	8.02
29-Jun	15:30	2.640	6.6	53.2	1.20	67.2	87.8	12.7	8.00
7-Jul	14:00	2.780	5.3	53.3	1.90	64.8	84.9	12.6	8.01
13-Jul	15:00	2.450	4.0	58.9	2.50	67.2	88.9	12.2	7.80
19-Jul	17:45	1.570	1.1	64.0	1.51	65.6	86.6	12.3	7.86
2-Aug	13:20	1.610	1.0	35.3	1.21	60.8	82.1	11.4	7.79
16-Aug	14:45	1.380	0.1	30.9	0.97	61.7	80.2	12.9	7.92
30-Aug	16:05	1.360	1.6	49.0	0.81	58.0	78.2	11.5	7.95
14-Sep	13:20	1.070	0.3	53.5	0.85	57.0	84.9	7.8	7.78
27-Sep	14:10	1.170	0.6	68.4	0.62	65.6	92.4	9.8	7.83
11-Oct	14:05		0.6	56.0	0.52	65.0	105.8	4.8	7.77
22-Oct	15:05		3.3	74.9	1.07	67.4	112.9	3.9	7.82

Table L2. Crazy Creek discharge and water quality data, 2006.

Date	Time	Stage (m)	Discharge (m^3/s)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Spec. cond. (µS/cm)	Temp. (°C)	pH
29-Mar	11:45		0.136	0.0	24.4		38.4	70.7	1.1	7.50
6-Apr	15:40		0.156	1.4	34.9		39.0	70.5	1.6	7.69
12-Apr	13:00		0.162	0.0	31.9	0.25	39.6	70.4	2.1	7.75
19-Apr	13:15		0.129	0.3	27.8	0.35	40.3	71.1	2.3	7.80
26-Apr	12:20	2.779	0.220	0.0	44.9	0.00	39.8	69.8	2.5	7.55
3-May	9:45	2.757	0.245	0.0	59.4	0.00	35.4	65.4	1.0	7.50
10-May	12:05	2.737	0.277	0.1	34.0	0.00	38.4	65.4	3.4	7.87
17-May	12:40	2.487	1.371	2.5	19.2	1.50	26.0	41.9	5.1	7.68
25-May	13:10	2.525	1.121	2.0	30.9	0.55	32.4	50.7	6.1	7.64
1-Jun	12:05	2.436	1.753	1.6	30.0	0.51	34.9	50.3	9.0	7.66
7-Jun	14:00	2.475	1.456	5.2	41.5	0.50	36.3	52.1	9.1	7.74
14-Jun	14:15	2.394	2.108	4.0	35.9	0.88	35.7	50.7	9.5	7.67
21-Jun	11:45	2.485	1.385	4.0	55.8	0.94	35.1	52.0	8.0	7.60
29-Jun	14:20	2.439	1.729	2.0	31.5	0.40	38.1	51.6	11.3	7.71
7-Jul	13:45	2.427	1.826	0.0	42.6	0.35	38.3	50.7	12.2	7.80
13-Jul	14:30	2.475	1.456	0.0	9.6	0.32	37.1	50.8	10.9	7.54
19-Jul	15:40	2.570	0.864	0.0	27.8	1.25	38.1	51.7	11.2	7.60
3-Aug	11:45	2.560	0.917	0.0	12.8	0.45	35.7	49.5	10.4	7.61
16-Aug	14:15	2.570	0.864	0.4	36.1	0.27	36.7	49.5	11.5	7.68
30-Aug	13:45	2.560	0.917	0.0	77.8	0.00	33.7	48.1	9.3	7.72
14-Sep	11:55	2.601	0.711	1.0	57.2	0.22	31.9	49.0	6.7	7.73
27-Sep	13:40	2.586	0.783	0.2	32.3	0.06	35.4	50.7	9.2	7.57
11-Oct	13:15	2.710	0.333	0.0	67.9	0.08	34.4	55.3	5.2	7.64
22-Oct	13:30	2.735	0.280	0.0	34.2	0.00	31.4	52.1	4.2	7.81

Table L3. Skinner Creek discharge and water quality data, 2006.

Date	Time	Stage (m)	Water depth in culvert (m)	Discharge (m^3/s)	TSS (mg/L)	TDS (mg/L)	Turbidity (NTU)	Conductivity (µS/cm)	Spec. cond. (µS/cm)	Temp. (°C)	pH
30-Mar	14:00			0.020	15.3	116.5		103.9	196.7	0.3	8.03
6-Apr	14:50			0.038	7.2	118.0		104.5	198.5	0.2	7.98
12-Apr	11:45			0.064	9.3	92.3	0.69	86.0	161.6	0.5	8.15
19-Apr	10:50			0.025	11.9	99.8	0.21	109.9	206.6	0.5	8.27
26-Apr	9:45	1.182		0.113	4.8	111.6	0.60	87.2	161.6	0.9	8.03
3-May	12:50	1.178		0.125	2.4	91.4	0.41	82.2	147.6	1.8	8.14
10-May	10:05	1.203	0.108	0.065	5.7	108.2	0.30	93.9	167.5	2.0	8.09
17-May	10:05	1.210	0.098	0.055	7.4	108.4	0.04	115.7	190.2	4.5	8.18
24-May	10:30	1.215	0.087	0.048	3.6	121.1	0.00	120.7	197.8	4.6	8.11
1-Jun	9:30	1.190	0.116	0.091	7.0	101.1	0.40	111.9	176.2	5.9	8.25
7-Jun	10:05	1.220		0.042	6.7	128.7	0.50	123.8	197.9	5.4	8.18
14-Jun	10:15	1.224	0.077	0.038	8.2	114.8	0.37	136.7	207.1	7.2	8.14
21-Jun	9:30	1.235	0.065	0.029	10.2	114.8	0.14	132.8	210.3	5.7	8.10
29-Jun	12:20	1.268	0.049	0.013	14.7	112.7	0.00	149.5	221.4	8.0	8.16
7-Jul	11:30	1.290	0.038	0.008	0.0	101.2	0.00	157.7	225.9	9.2	8.27
13-Jul	12:20	1.277	0.039	0.010	7.5	132.8	0.00	146.1	213.3	8.5	7.99
19-Jul	13:05	1.286	0.038	0.008	0.5	108.0	0.00	158.1	229.6	8.7	8.13
2-Aug	10:45	1.317	0.031	0.004	1.0	105.8	0.03	162.9	237.2	8.6	7.99
16-Aug	7:12	1.320	0.029	0.004	9.2	101.2	0.00	166.3	238.2	9.2	7.98
31-Aug	10:55	1.307	0.033	0.005	6.0	119.7	0.00	154.7	232.4	7.5	8.02
14-Sep	9:50	1.263	0.048	0.015	13.8	133.8	0.00	143.8	232.0	5.1	7.89
27-Sep	10:20	1.270	0.044	0.012	0.1	130.8	0.00	138.7	214.5	6.5	8.00
11-Oct	10:55	1.272	0.044	0.012	0.0	143.7	0.00	126.0	212.4	3.7	8.00
22-Oct	12:20	1.270	0.044	0.012	3.0	101.5	0.00	105.1	178.9	3.4	8.04