BOWKER CREEK
WATERSHED ASSESSMENT

Prepared for:

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EXECUTIVE SUMMARY

An assessment has been completed for the Bowker Creek watershed, which lies within the municipalities of Saanich, Victoria and Oak Bay and includes approximately 1028 hectares of mainly residential development. The total length of the stream mainstem is approximately 8000 metres. Of this, there remains approximately 2500 metres of open watercourse on the mainstem.

The project methodology included a review and use of previous work by:

- Friends of Bowker Creek Society (creek history, media reports, mapping, student reports and stewardship activities).
- Capital Regional District (CRD) (historical water quality data).
- Municipal governments (reports and designs including Saanich's Environmentally Sensitive Areas atlas).
- Engineering consultants (flood reports).

Digital base mapping was assembled for the watershed from files provided by each of the three municipalities. Field inspections were completed and a water quality sampling program was designed to examine low flow conditions. Parameters sampled include dissolved oxygen, conductivity, pH and water temperature. The consultants also met with the engineering representatives of each of the three municipalities to determine their issues and plans regarding Bowker Creek.

The Bowker Creek condition has been assessed for:

- Water Quality;
- Aquatic Fauna;
- Vegetation;
- Recreational Use; and
- Hydraulics.

Water Quality

The historical water quality analysis shows that fecal coliform counts have declined since 1982 when the CRD started sampling Bowker Creek. The decline is likely attributable to the ongoing work by Oak Bay, Saanich and Victoria to eliminate cross connections between sanitary sewer lines and storm drain pipes.

The CRD also evaluates storm water discharges into coastal waters by sampling creek sediments for chemical contaminants. These sediments were analyzed for eight metals and two groups of

organic contaminants in 1993 and 1997. The concentrations of contaminants at the mouth of Bowker Creek were well below the limits set by the Marine Sediment Quality Guidelines as adopted by the CRD. The summer 2000 water quality monitoring program completed for this project confirmed that acceptable levels of dissolved oxygen, conductivity, pH and water temperature for aquatic life exist in Bowker Creek. However, there is evidence from Douglas Creek (located north of Bowker Creek and similarly urbanized) showing that sudden and dramatic negative changes in water quality can occur during "first flush" rainfalls after prolonged dry periods.

Aquatic Fauna

The status of aquatic biota, including amphibians, fish and aquatic invertebrates was investigated. There is only anecdotal evidence on amphibian presence and it indicates that frogs are no longer heard in portions of the creek where croaking was heard three or four years ago. Exhaustive fish sampling in 1988 determined that the only place where fish were found was between tidewater and the first long culvert at Monteith Avenue. Only sculpin and stickleback were found at this location. Based on the type and distribution of benthic invertebrates found, water quality can be considered "fair" as there is a lack of pollution sensitive species that would allow water quality to be classified as "good".

Vegetation

The existing earthen banks are generally very steep (1:l slope) and composed of clay tills, but are relatively stable due to high resistance to erosion. The steepness of the banks limits the amount and type of streamside vegetation that can develop, hence many riparian tree and shrub species are not present. Additionally, the steep banks (many with lock block, gabion or concrete reinforcement) and thick blackberry patches make much of the channel inaccessible. A chief concern regarding vegetation is the presence of golden or yellow willow which will out-complete native willows and other species of plants and trees and is a major user of creek water. In some areas, large willow root mats have eliminated the natural channel bed and associated invertebrate production. They could be lifted off the bed during storm events and create a blockage to flood discharge.

Recreational Use

Bowker Creek flows through only two designated parks; Browning Park in Saanich, north of McCrae Avenue and Bowker Creek Park in Oak Bay, however most open sections of the creek can also be accessed by the public through a number of undeveloped properties and the Richmond Elementary School yard. Some of these routes are used so frequently that dirt paths have been worn into the ground cover vegetation.

Community groups and municipal planners are advocating the preservation of open sections of Bowker Creek and exploring the feasibility of creating a greenway along the stream and rehabilitating portions of the stream channel to improve biodiversity. The agencies involved in these initiatives include:

- Provincial Capital Commission (Community Greenways Strategy)
- Capital Regional District (Regional Green/Blue Spaces Strategy)
- District of Saanich (Shelbourne Local Area Plan and a Municipal Green/Blue Spaces Strategy)
- Capital Health Region (Concept planning for rehabilitation of the section of creek within the Royal Jubilee Hospital grounds)
- Friends of Bowker Creek (community-based action)
- Ecotrust Canada Mapping Office and Victoria Natural History Society through its subsidiary. Habitat Acquisition Trust Foundation (GIS database prototype project for Bowker Creek)
- Camosun Community Association (a project entitled Supporting a Regional Vision for the Bowker Creek Corridor: Community Awareness and Extension Tools)

Hydraulics

Hydraulic limitations of varying severity occur along some of the open channel and enclosed reaches of the creek. The two most severe limitations occur at entrances to enclosed sections, namely at Monterey Avenue and Trent Street. At Monterey Avenue overflows due to extreme floods will inundate portions of Fireman's Park, but it is not believed many private buildings would be flooded. At Trent Street high water occasionally floods the St. Patrick's School building and threatens a number of surrounding properties. Comprehensive studies have not been completed for these sites, but it is believed the unsurcharged hydraulic capacities of the creek are limited to the **5-1**0 year return period floods. Flooding on Bowker Creek spans three municipalities and represents a complex problem with potentially high costs for remediation. Further remediation activities could include investigations of capacity enlargement, channel dyking, purchasing flood-prone land or providing stormwater storage areas to attenuate flows. **A** number of potential floodplain widening areas have been identified which, if implemented, would help attenuate flood flows and inundation depths. The benefits and costs of the options could be studied to determine the feasibility of structural improvements for these areas.

A channel maintenance program is needed for all reaches that allows for establishment of an optimum waterway area and replanting with appropriate species that would ensure adequate capacity at all times, not just in the period following bank cleaning. For example, the open channel sections behind *Oak* Bay High School and beside the *Oak* Bay Recreation Centre are overgrown with vegetation that adversely affects their limited capacity.

Issues and Remediation Options

The following issues and remediation options should be considered in any subsequent planning process for the Bowker Creek watershed.

- There are a number of water quality conditions that appear to make it very difficult to maintain diverse fish populations in the creek;
- Continued improvements in water quality would help protect the marine receiving environment and improve benthic invertebrate populations;
- Control and treatment of drainage from high traffic areas will help continue the improvement in water quality that has occurred in recent years;
- Continuous monitoring of Bowker Creek water quality would help to assess whether fish can eventually be supported;
- Daylighting any additional portions of creek is not considered feasible at this time due to anticipated high costs and the greater need to rehabilitate the existing portions of open channel;
- There is a community will to maintain and rehabilitate the open channel portions of Bowker Creek;
- Consider designating land adjacent to Bowker Creek as linear park or greenway as these sections are presently well used by the public;
- A number of different options exist for dealing with some of the flooding issues associated with the creek. These could include: channel enlargement, dyking, purchasing flood-prone land and restructuring adjacent lands to facilitate additional stormwater storage;
- The existing baseflow channel should not be widened for full-time ponds or wetlands as these will increase the exposure of the water surface to sunlight, thus risking water quality impacts, and;
- The restructuring of the banks for stormwater storage should also consider the development of native riparian vegetation and access for people.

Recommendation

It is recommended that the CRD, in consultation with municipal government, community groups and others, guide the formation of a Watershed Management Forum for the Bowker Creek watershed. The objective of the Forum would be the development of a Watershed Management Plan for the Bowker Creek watershed.

BOWKER CREEK WATERSHED ASSESSMENT

1.0 INTRODUCTION

Reid Crowther and Partners Ltd. (RCPL) and SHIP Environmental Consultants Ltd. (SHIP) were commissioned by the Capital Regional District to prepare an assessment, for the Bowker Creek watershed. Reid Crowther has provided the engineering content while SHIP has provided services relating to water quality. aquatic biota, and recreational assessments for this project. Engineering issues include hydraulic capacity, stormwater control and pollution control.

2.0 DESCRIPTION OF WATERSHED

The Bowker Creek watershed is approximately 1028 ha in area and lies within the municipalities of Saanich, Victoria and Oak Bay ***(Figure 1)***. The headwaters of the catchment include the University of Victoria, the McKenzie Avenue area and the Cedar Hill Golf Course. Other portions of the catchment include the Shelbourne Valley, Cedar Hill Road. Richmond Road, the Doncaster area and the Fort Street drainage basin. The catchments areas by municipality are as follows:

Saanich	613ha
Victoria	236 ha
Oak Bay	170 ha
TOTAL	1028 ha

The basin is gently sloped, having typical gradients between 1% and 4% and the main channel has an average gradient of 0.5% in the upper reaches which reduces to less than 0.4% in the lower reaches

The catchment is highly developed and now contains a wide range of land use which is predominantly residential. As a result of this development, all of the creek sections have been either enclosed in a storm drain or left open but channelized. Slightly more than half (2500 m of a total length of 4850 m) of the lower watershed (downstream of Knight Avenue) remains in open, but modified channel. While the majority of the flow within the "upper watershed" is within storm drains, there are two open sections found on tributaries to the main channel. There are 250 m of open channel at Cedar Hill Recreation Centre and Golf Course properties and 500 m at UVic between Gordon Head Road and Ring Road. The total length of the main stem from Ring Road to the creek mouth is approximately 8000 m.

Most of the upper Bowker Creek watershed and all portions of the stream channel in the City of Victoria have been enclosed in a storm drain system. The eight sections of channel which remain open but modified are found: (Figure ***2):***

- between the mouth (Stn 0+00) and the Monteith Street culvert (Stn 2+54)
- between the Monterey Avenue culvert (Stn 5+62) and the Tennis Bubble culvert (Stn 9+86)
- between the Tennis Bubble culvert (Stn 10+62) and the Cadboro Bay Road culvert (Stn 12+88)
- between the Trent Street culvert (Stn 15+14) and the Richmond Road culvert (Stn 20+88)
- between the Newton Street culvert (Stn 22+92) and the Pearl Street culvert (Stn 27+08)
- between the Shelley Street culvert (Stn 40+08) and the Knight Avenue culvert (Stn 46+50)
- tributary 1 – upstream of Cedar Hill Road culvert (Stn 101+62), and
- tributary 2 – upstream of Gordon Head Road culvert.

In most places, the channel has been straightened, native vegetation removed, and artificial banks constructed. The land status of each open section of channel as well as recreational use, crown closure, confinement, and bank composition are found in Appendix A.

It is understood that through most of the reaches illustrated in Figure 2, all storm drains and culverts have been built to a gradient that was struck by City of Victoria Engineer Topp in the 1930's. (Topp's Grade = 0.369%).

3.0 METHODS

3.1 Data Collection

Initially, existing information about Bowker Creek was collected from the Friends of Bowker Creek Society. The material included a brief history of the stream. media reports, historical and GIS mapping (ArcExplorer format). University of Victoria and Camosun College student reports, and stewardship activities of the society. Historical water quality data was obtained from the Capital Regional District. Further inquiries were made of municipal, regional, and provincial government staff as well as other consultants who had done work in parts of the system.

Digital cadastral mapping of the watershed was obtained from the three municipalities through which Bowker Creek flows. Saanich also provided digital planimetry and topography and the City of Victoria provided digital planimetry and existing storm drains. Saanich and *Oak* Bay provided paper copies of the existing storm drains.

The *Saanich Environmentally Significant Areas* atlas was also consulted. It includes the portions of the Bowker Creek channel that are contained in Victoria and *Oak* Bay.

3-2 Field Inspections and Sampling Program

Consultants from RCPL and SHIP conducted a joint site visit on July 21. 2000. All of the open sections of Bowker Creek that flow through public property were surveyed. SHIP collected information regarding the following:

- bank composition and stability,
- bed material.
- benthic invertebrates,
- crown closure,
- land statue and recreational use, and
- potential storm water storage sites.

A water quality sampling program was designed to examine the water quality conditions during the low flow period.

In the first round of sampling four parameters (dissolved oxygen, conductivity, pH, and water temperature) were measured at 21 sites (Figures 3 to 9). The number of sampling sites was reduced to 13 for the second and third visits, as the other eight sites provided no additional information. See ***Table*** 5.4 for results.

Because Bowker Creek is an urban watershed that has been significantly impacted by development, it would not be useful to evaluate its health compared to relatively natural systems. Thus, information regarding another very similar local urban stream, Douglas Creek, was obtained from Friends of Mount Douglas Park to provide a basis for assessment.

4.0 ENGINEERING INFORMATION

4.1 Previous Engineering Studies

1. Report on Bowker Creek Flooding at North Dairy Road for Killam, Whitelaw and Twining, Barristers and Solicitors by Ker Priestman & Associates Ltd.. November 1983.

This study was in response to a lawsuit for flooding and examined the design criteria, design flows, hydraulic capacity and the standard of construction of the North Dairy Road storm drain in Saanich. This 160 m extension of the storm drain on Doncaster Road was completed in November 1981. In January 1982 the drain overflowed from the new inlet in Saanich and flooded 70 residences in the Doncaster area of Victoria. The drain was designed for a 25-year return event but the inlet area was left unfinished and a trashrack was installed that had very little factor of safety against blockage of the inlet by debris. The inlet did become blocked and was the cause of the overflow. The estimated peak runoff during the event was 4.9 m^3/s (10 – 15 year return). well under the design flow of 11.2 $m^3$is or the unsurcharged inlet capacity of 7.5 m^3/s. Since the 1982 overflow the inlet design has been modified to maximize the hydraulic capacity and minimize the probability of a blockage.

2. Report on Flood Flows and Stormwater Storage in the McKenzie Avenue Section of Bowker Creek for the District of Saanich by Ker Priestman & Associates Ltd., April 1983.

The purposes of this study were to evaluate the Bowker Creek flood of December 2, 1982 and to investigate stormwater storage alternatives on the University of Victoria property at Gordon Head Road near McKenzie Avenue. The study investigated whether the available impoundment volume could provide sufficient flow attenuation to prevent overloading of the downstream sections of the storm drain during a 25-year return period flood. The critical capacity section is between Gordon Head Road and Shelboume Street, near Garnet Road, and had a capacity of 1.4 $m^3$is (5-year return). The calculated 25-year flow at this point is 2.6 m^3/s. The analysis determined that a 16,000 m^3 impoundment could attenuate the flow sufficiently to prevent overflow during the 25-year flood. Preliminary engineering information for the detention facility was provided in the report but construction costs were not estimated and it has not been constructed to date.

Although not discussed in the report, the potential impoundment could also have minor benefits in the Trent Street reach that is also known to flood. At that

location the catchment area is 962 ha, and the potential 16.000 m" volume. which is 17 m^3 per hectare of catchment, would be expected to reduce peak flows by several percent.

3. Report on Flood Flows in Bowker Creek- Haultain Street to the Oak Bay Recreation Centre for the District of Saanich and the City of Victoria by Ker Priestman & Associated Ltd., February 1984.

The purpose of this study was to evaluate the January 1982 flood event for the reach from Haultain Street to the *Oak* Bay Recreation Centre and ascertain if there were any constraints within the reach that could affect flood levels. A hydraulic grade corresponding to the January 1982 event was calculated and showed that flooding in the vicinity of 2456 Trent Street was likely the result of poor hydraulic conditions and/or inadequate channel capacity in Bowker Creek upstream from the concrete box culvert at Trent Street (2.4 m x 2.4 m), which were aggravated by high transition and bend losses in the Trent Street culvert plus poor channel hydraulics in Oak Bay near the Recreation Centre. Following the flood, the open channel reaches were cleaned and improved but it is believed that no further significant action has been undertaken since that time. A 25-year design flow ranging from 19 to 23 m^3/s and a hydraulic grade were established in the report and the related hydraulic improvements and enclosures were indicated. These facilities, which included additional sections of box culvert. would have a relatively high cost (that was not estimated) compared to recent flood damage.

The report recommended that other options, such as dyking the channel through the reach in question, buying the land that is subject to flooding. providing detention storage, designing improvements to other criteria or simply doing nothing, should all be investigated before implementing the works. These options could be studied on a benefit/cost basis, but this has not been done.

4. Report on Hydraulic Analysis of Bowker Creek and Assessment of the November 1990 Flood for the Corporation of the District of *Oak* Bay by Charles Howard and Associates Ltd., July 1992.

The purpose of this report was to determine the cause of flooding along Bowker Creek during two consecutive November 1990 storms and determine if there were limitations in the drainage system through Oak Bay requiring correction. The report concluded the frequency of the November 1990 events was between 15 and 25 years and that due to the long duration of the events they would probably have resulted in about the same peak discharge even in the absence of urbanization. Local flooding occurred near the Monterey Avenue culvert entrance and adjacent

to Fireman's Park. The channel upstream from the Monterey Avenue culvert through Oak Bay did not overtop and the hydraulic analysis showed that the channel capacity in this section is sufficient to handle peak flows at the 50 year return period (but no field measurement of channel size were taken and there has been no channel clearing since that time). The report recommended examining the feasibility of providing upstream storage in cooperation with the municipalities Saanich and Victoria (no action to date), examining the feasibility of increasing the capacity of the Monterey Avenue culvert (no action to date). installing a flow gauge (done, but now not used), increasing the capacity of the channel through Oak Bay (no action. except for the short section upstream from Bee Street) and providing a safe overflow path across Fireman's Park (designed but not yet approved).

4.2 Municipal Engineering Input

Meetings were held with engineering representatives of the three municipalities in August 2000. A summary of their comments regarding Bowker Creek interests, concerns and plans follows:

District of Saanich

Since January 1982, Saanich has been acutely aware of the potential flooding issues associated with the creek, and in particular, the threat of potential blockage at the inlets to the various sections of storm drain. At that time the inlet to the North Dairy storm drain, north of Hillside Mall, became blocked with debris that had accumulated in the open section of creek and had been carried down to the inlet during the flood. The material was swept onto the safety grillage and substantially blocked the flow. The overflow reached the low-lying Doncaster Street area behind Hillside Mall and caused significant damage. A class action lawsuit was successfully launched against the District on behalf of the affected property owners. Since then the Public Works department has been diligent about regularly monitoring the condition of the channel. Some channel sections were mechanically cleared following the 1982 flood, but there has been no such recent activity, due to concerns with bank stability and ecological impact, such as loss of tree canopy.

The municipality is also aware of the flood zone or overbank issues associated with the open channel reaches. These include a flood construction elevation, a prohibition on fill placement within the flood zone, and consideration of stormwater storage options to help alleviate downstream flows. In particular the property at 1880 Adanac, for example, has been denied a building permit and no landfilling has been allowed on

this site. The engineering department has examined the feasibility of stormwater detention at the following sites, including:

- The west side of the University of Victoria at Gordon Head Road:
- The BC Hydro property, north of Haultain Street; and at
- Richmond Elementary School

No action has been taken on these options, except to request a land reserve at UVic covering the area of the potential detention pond site.

Despite the high degree of urbanization and limited recent improvements to the channel, reported flooding episodes have been rare and limited to specific locations. These include the box culvert at Church Road near Shelboume Street and the Trent Street area immediately upstream (north) from the City of Victoria boundary. No specific hydraulic improvements are planned by Saanich. No reaches have been identified for potential daylighting. There is a short section through a parking lot south of Mortimer that could be opened but at this time there are no driving factors for creek daylighting.

Regarding water quality, the District is working towards a municipality-wide requirement for storm water control plans for new development and the implementation of oil/grit separators for pavement drainage that would help protect creek water quality and habitat.

City of Victoria

The City's primary concern with Bowker Creek is the intermittent flooding that occurs in the Trent Street area. The residents expect the City to improve matters but the City is concerned that hydraulic improvements at Trent Street may simply transfer the problem downstream into Oak Bay. The City believe the problem may be due to the transition from open channel to storm drain at St. Patrick's School and have considered whether low dykes along the channel would help the situation. Otherwise the capacity within the City appears adequate, but City staff remain concerned about a reoccurrence of the January 1982 flood event. There have been approximately five flooding occurrences at Trent Street in the past 30 years, including December 1999, November 1990 (2 events), December 1982 and January 1982.

Daylighting the creek in Victoria does not appear to be an option unless there were sufficient funds to purchase the adjacent properties and create an appropriately sized channel. The City also reports that through the enclosed Doncaster reach there is a lot

of sediment accumulation which may be detrimental to the aesthetics of an open channel. Regarding catchment area management, the City is now much more aware of water quality control due to its recent project on the daylighting of the lower portion of Cecelia Creek. The City's first priority is improving the drainage water quality into the Harbor which flows from the industrial and commercial areas of the City. Therefore it is unlikely any special efforts will be made in the short term to target discharges from the residential areas to Bowker Creek, which are believed to be of better quality. Occasionally oil from leaking underground oil tanks seeps into the creek but these problems are usually quickly rectified. The City is working towards an improved City-wide oil and grit control program involving the use of larger catchbasins with trapping hoods.

District of Oak Bay

Oak Bay's concerns relate to being the recipient of runoff from large impervious areas in the upstream watershed and staff feel that stormwater detention for such areas as the Hillside Mall parking areas would be beneficial. The section with limited capacity is the long culvert under Fireman's Park, but an overflow has only been recorded once (November 1990). Since 1990 full conditions have been reported twice. Only two houses appear to be affected by flood conditions (one on Monteith Avenue and one below Beach Avenue). There is no information for the 1982 events.

The District has examined the feasibility of bank improvement in the reach downstream from Fort Street/Cadboro Bay, but to date no funds have been allocated. This work may involve the enlargement of the channel through the use of structural means, such as a concrete retaining wall, lock blocks or gabions.

Regarding water quality, the District has an active cross connection control program and they believe that there are no problems in the Bowker Creek watershed. They are also working on a standard detail for catchbasins that would improve oil and grit trapping.

The District owns a flow depth-monitoring gauge that is installed at the Tennis Bubble, but it is not in use at present.

5.0 RESULTS

5.1 Present Status of Bowker Creek Water Quality

5.1.1 Fecal Coliform Levels

The Capital Regional District (CRD) water quality sampling program monitors levels of fecal coliforns (bacteria found in human and animal waste) which are used as an indicator of the level of pollution in a watercourse. The CRD has been recording fecal cohform levels at the mouth of Bowker Creek (Stn 316-1) since 1982 and in open sections of the channel at the Oak Bay/Saanich boundary (Stn316-3) and Saanich/Victoria (Stn 316-4) boundary since 1994 ***(Table*** 5.7).

At Stn 316-1, high fecal coliform levels (1,000–19.000 coliform/100 mL) were recorded from 1982 to Aug 1999. The lowest fecal coliform levels recorded were in Sept 1999 (530 coliform/100 mL) and Feb 2000 (620 coliform/100 mL). Sample sites **3**16-3 and **3**16-4 show similar reductions in the fecal coliform levels during the spring and fall of 1999. The decline is likely attributable to the ongoing work by Oak Bay. Saanich, and Victoria to eliminate cross connections between sanitary sewer lines and storm drain pipes. As elimination of cross connections is an ongoing process with the municipalities, there should continue to be steady improvement in fecal coliform levels.

5.1.2 Storm Water Discharge Sampling Program

The CRD evaluates the sediments associated with storm water discharges into coastal waters for environmental concerns by sampling at the outfall of streams and storm water pipes. The levels of eight metals and two groups of organic contaminants in the sediments are compared to the marine sediment quality guidelines (MSQG) that have been adopted by the CRD. The results for Bowker Creek are shown in ***Table*** 5.2. Because the levels are all well below the guidelines, the CRD assigned a rating of "low" to Bowker Creek in both 1993 and 1997, and plans to sample the outlet again in 2002. The reader may refer to Hull and Miller (2000) and Humphrey (1999) for details of the sediment sampling program.

Table 5.1 CRD Fecal Coliform sampling results for Bowker Creek 1982–1999 (Coliforms/100mL)

Date **Sampled**	Station Number		
	316-1	316-3	316-4
82-Dec	8,000		
84-July	2,100	-	-
85-Feb	3,100	-	-
85-July	4,700	-	-
88-Mar	3,200	-	-
88-Aug	15,000	-	-
89-May	6,400	-	-
89-June	6,300	-	-
89-July	4,800	-	-
89-Aug	3,000	-	-
89-Sept	17,000	-	-
90-Feb	1,100	-	-
90-Aug	9,000	-	-
91-Mar	4,700	-	-
91-July	12,000	-	-
91-Aug	11,000	-	-
92-Mar	11,000	-	-
92-July	5,500	-	-
93-Jan	5,800	-	-
93-June	19,000	-	-
94-Jan	2,100	-	-
94-June	2,000	-	-
94-Aug	3,500	840	230
95-Jan	3,000	-	-
95-Feb	2,000	11,000	400
95-July	2,000	-	-
95-Oct	2,200	-	-
96-Feb	2,000	-	-
96-Mar	2,100	3,900	870
96-June	2,200	-	-
96-July	11,000	13,000	2,500
97-Jan	1,400	-	-
97-Feb	1,000	510	210
97-June	13,000	-	-
97-Sept	1,400	3,100	4,600
97-Nov	7,900	-	-
98-Jan	2,000	-	-
98-June	4,300	2,200	200
98-July	1,000	-	-
98-Aug	1,400	1,700	330
99-Jan	5,300	-	-
99-May	2,000	390	240
99-Aug	3,300	-	-
99-Sept	530	290	160
00-Feb	620		

Notes: *1. **Sin 316-1: mouth of creek***

*2. **Stn 316-3: near Victoria/Oak Bay border at Bee Street***

*3. **Stn 316-4: near Saanich/Victoria border at North Dairy Road***

Table 5.2 Results of CRD sampling for chemical contaminants at the Bowker Creek outlet (Hull and Miller 2000)

Date sampled	Arsenic µg/g	Cadmium µg/g	Chromium µg/g	Copper µg/g	Lead µg/g	Mercury µg/g	Silver µg/g	Zinc µg/g	LPAH µg/g	HPAH µg/g
MSQG	57	5 1	260	390	450	0 41	61	410	5.2	12
1993	2	0 l	8	16	24	0.07	0.0	68	0 2	l
1997	1	0 2	28	29	102	0.02	01	109	0 3	1

Notes

1 MSQG: Marine Sediment Quality Guidelines
2. LPAH: low molecular weight polycyclic aromatic hydrocarbons
3. HPAH: high molecular weight polycyclic aromatic hydrocarbons
4. µg/g: micrograms per gram (parts per million)

5.1.3 Summer Water Quality

In September 1999, the CRD Stormwater Quality Program expanded to include measurements of temperature, pH, and dissolved oxygen in Bowker Creek ***(Table*** 5.3). These results suggest that the water quality in these open sections of Bowker Creek falls within the range of conditions typically found in streams throughout Greater Victoria and the Saanich Peninsula. As a result, it was decided as part of this study to further measure dissolved oxygen, water temperature, pH, and conductivity several times in July/August 2000, at a number of sites over the length of Bowker Creek. These results are shown in ***Table*** 5.4.

Table 5.3 Results of water quality sampling by the CRD

Station No.	Location	Date	Temperature (°C)	pH	Dissolved Oxygen (mg/L)
316-1	point of discharge into Oak Bay	99 Sept 14	15.3	7.3	8.2
316-3	near Victoria / Oak Bay border at Bee St	99 Sept 14	17.5	7.6	6.8
316-4	near Saanich / Victoria border at North Dairy Rd.	99 Sept 14	18.1	7.5	5.4

These results show that acceptable dissolved oxygen levels were maintained throughout the summer as were stream temperatures (15–18°C range). The pH values appear normal, except for the July 26, 2000 readings when instrument calibration may have been a problem. Conductivity levels show a generally increasing concentration of dissolved nutrients as summer progressed, likely attributable to a reduction in stream flows that increased the concentration of dissolved materials. It was also

Table 5.4
Summer 2000 Water Quality

Site	Location	Station	Air Temp (°C)			Water Temp (°C)				Dissolved Oxygen (mg/L)			Conductivity (uS/s)				pH		
			Jul 25	Aug 16	Sep 07	Jul 25	Aug 16	Aug 29	Sep 07	Jul 25	Aug 16	Sep 07	Jul 25	Aug 16	Aug 29	Sep 07	Jul 25	Aug 16	Sep 07
1	downstream of Beach Rd. culvert	0+70	22.0	22.0	14.0	17.0	15.0	18.5	14.5	9.3	9.4	9.3	393	381	138	354	8.8	7.5	8.3
2	upstream of Monterey Ave.	5+75	22.0	18.0	12.5	17.0	16.0	—	14.0	9.2	10.6	7.7	370	372	—	365	8.5	7.7	8.1
3	Bowker Creek Park between foot bridges	7+10	21.0	22.0	13.5	18.0	16.0	—	14.0	6.5	8.4	6.4	323	362	—	382	9.1	8.6	8.0
4	downstream of Tennis Bubble at Oak Bay Rec	9+75	23.0	—	—	17.5	—	—	—	9.2	—	—	292	—	—	—	8.8	—	—
5	upstream of Tennis Bubble at Oak Bay Rec Centre	10+70	24.0	—	—	18.0	—	—	—	9.6	—	—	294	—	—	—	8.9	—	—
6	downstream of Bee St. culvert	12+10	23.5	19.0	14.0	19.0	17.0	—	14.5	10.2	10.1	7.8	290	397	—	395	9.1	8.1	8.0
7	upstream of culvert at St. Patrick's School	15+15	26.0	17.0	12.0	21.0	16.0	—	15.0	10.5	7.7	11.9	247	386	—	410	9.5	7.9	8.4
8	near Royal Jubilee Hospital NE parking lot	16+80	28.0	—	—	20.0	—	—	—	10.0	—	—	248	—	—	—	9.2	—	—
9	downstream of Haultain St.	18+45	24.0	—	—	19.0	—	—	—	8.2	—	—	254	—	—	—	8.8	—	—
10	upstream of Haultain St. (BC Hydro property)	18+80	24.0	—	—	19.0	—	—	—	8.7	—	—	251	—	—	—	8.8	—	—
11	near large Pacific willow (BC Hydro property)	19+80	24.0	—	—	19.0	—	—	—	8.7	—	—	249	—	—	—	8.8	—	—
12	downstream of Richmond Ave.	20+80	25.0	21.0	13.5	19.0	17.0	—	15.0	8.9	8.5	8.5	258	403	—	389	9.0	7.8	8.0
13	upstream of Newton Ave. (Richmond School)	22+95	27.0	23.0	—	17.0	18.0	—	—	8.6	9.7	—	278	398	—	—	9.1	8.0	—
14	upstream of lock-block wall at Richmond School	24+30	23.0	—	—	18.5	—	—	—	8.0	—	—	295	—	—	—	8.7	—	—
15	downstream of Pearl St.	27+05	22.0	23.0	13.0	18.0	17.0	—	15.5	9.1	8.9	8.7	311	383	—	367	9.0	8.0	7.8
16	Keats St. Bridge	41+55	23.0	24.0	14.0	18.0	17.0	—	15.0	7.6	8.4	7.2	318	417	—	398	8.6	7.7	8.1
17	Wordsworth St. Bridge	42+80	23.0	21.0	13.5	18.0	18.0	—	15.0	7.3	7.8	8.6	339	417	—	396	8.5	7.3	8.1
18	downstream end of Browning Park	45+05	21.0	—	—	18.0	—	—	—	7.9	—	—	365	—	—	—	8.5	—	—
19	upstream end of Browning Park	46+25	20.0	21.0	13.5	18.0	18.0	19.5	16.0	8.0	7.9	7.8	366	402	154	401	8.6	7.6	8.1
20	upstream of ball fields at Cedar Hill Rec Centre	104+40	18.0	17.0	16.0	16.0	16.0	—	13.5	6.3	5.1	6.8	149	116	—	107	8.1	7.1	7.3
21	UVic wetlands along Gordon Head Rd.		23.0	17.0	17.0	17.0	16.0	—	14.0	5.8	4.5	4.4	212	260	—	278	8.1	7.3	7.4

apparent that higher conductivity levels are present below the culvert outlet at Browning Park (Knight Avenue) and again in Bowker Creek Park in Oak Bay

5.1.4 Discussion

The relatively moderate summer water temperatures of 15–19°C can be attributed to the cooling effects of the long culverted sections and the reduction of direct radiation on the open channel sections due to the existing tree canopy cover. The high quality oxygen concentrations (7-10 mg/L) are likely attributable to the moderate water temperatures and continuous stream flow all summer. There are also a number of small riffles and vertical drops throughout the stream channel that provide natural aeration of the water. Conductivity levels indicate greater than desirable levels of dissolved nutrients. It is not known whether it is possible to reduce levels as it is suspected that during the summer most of this material is entering the system through groundwater seepage. Water pH levels appear to be what should be expected for most streams in the region.

Most of the information collected shows improving water quality conditions or water quality conditions that are typical for streams throughout the Greater Victoria area. However, these data do not provide the total picture of water quality conditions. Water quality data was also obtained from Mr. Bob Bridgeman (Friends of Mount Douglas Park) for Douglas Creek, another urban stream located to the north of Bowker Creek. Douglas Creek exhibits similar summer water temperature, conductivity, pH and dissolved oxygen values as Bowker Creek. However, because of a weekly water-quality sampling program in Douglas Creek in 1996 and 1997. some sudden and dramatic changes in water quality conditions were noted. In particular, the first fall rainstorm event that occurred Oct. 12–14, 1996 created a significant change in water quality. Conductivity readings preceding and following the event ranged from 160 to 260 μS/s. During the Oct. 12 rainfall event, the conductivity increased seven fold to 1200 μS/s. Hence, for a one or two-day period, the level of dissolved nutrients or contaminates greatly exceeded normal levels. Through this period as well there was an eight fold increase in suspended sediment and, during this Oct. 12 storm event, there was a reduction of dissolved oxygen levels from near 100% saturation to 40% saturation at the discharge site of the storm drain system associated with Douglas Creek.

A small rainfall event occurred at Bowker Creek on August 29, 2000. After about 6 hours of rainfall, it was realized that this was becoming an intensive rainstorm and two sites (#l and #19) were quickly sampled for temperature and conductivity. Conductivity levels were approximately 50% lower than typical levels recorded earlier. Water temperature had increased by at least 2°C, turbidity had reduced

visibility from clear to 15 cm, and the water depth had increased by 30 cm. Because sampling occurred 6 hours after the start of the storm event, it is likely any sudden increase in conductivity' associated with the "first flush" (dissolved nutrients) in the first few hours could have already abated.

The above results demonstrated that water quality conditions can be significantly altered in an urban stream over a very short period of time. Therefore, potential short duration rainfall events must be given much more weight when the health of an urban stream is considered. Therefore, if such conditions occur in Douglas Creek, where only the upper watershed is within an urban setting, it could be expected that during rainfall events even more significant changes in water quality will occur in Bowker Creek than were documented in Douglas Creek.

As a result of fish mortalities in Douglas Creek, there is a desire by Friends of Mount Douglas Park to identify the factors that may be responsible. When the data collected for these two streams is considered, it is likely there are a multitude of factors that contribute to fish mortalities. In a summer rainfall event all the following changes in water quality occur at the same time:

- increase in water temperature,
- increase in dissolved nutrients,
- increase in turbidity,
- increase in water velocity and discharge, and
- reduction in dissolved oxygen levels.

Any one of these factors on its own may increase the stress level on fish for a short period of time. However, if all five factors occur at once there is likely a cumulative effect on the stress level on the fish species. This may affect some fish in the population more than others and one should expect that some mortalities may occur, depending on the health of individual fish. Effects may vary from mortality' to impaired development or disorientation resulting in relocation to poorer quality habitats downstream.

5.2 Present Status of Bowker Creek Aquatic Biota

5.2.1 Amphibians

There is little anecdotal information about amphibians in Bowker Creek. Norris (1988) observed three tadpoles at one of his fish sampling sites in the middle portion of Bowker Creek. Three or four years ago, abundant frog croaking could be heard on portions of Bowker Creek. but none in recent times (Graeme pers. comm.).

5.2.2 **Fish** Presence

The most recent and exhaustive fish sampling was conducted by Norris (19881. Mr. Norris conducted fish sampling surveys throughout the length of open channel portions of Bowker Creek. The only place fish were found was in the portion of the creek from tidewater to the outlet of the first long culvert at Monteith Street In this portion of channel, he found two species of freshwater sculpins, prickly sculpin *(Cottus asper)* and coast range sculpin (C. *aleuticus).* These fish are often incorrectly called bullheads when marine forms are seen in tide pools. The other fish found is the three-spine stickleback *(Gasterosteus aculeatus).* Illustrations of these three species of fish are found in ***Appendix*** B. The three spine stickleback is a small minnow-sized fish that, as the name suggests, has three spines on the top of its back. All three species of fish are native to Vancouver Island and have a tolerance for low oxygen conditions and all three species are able to live for extended periods in marine environments. This may explain why these species were found only in the portion of stream channel easily accessible from the marine environment.

As stated. no other fish were captured in the other open portions of Bowker Creek. As well, there were no other incidental observances of fish reported in discussion with local stewardship groups and in examination of reports completed on Bowker Creek.

5.2.3 Benthic Invertebrates

The results of a benthic invertebrate survey provide an indication of water quality in a stream due to the varying tolerance to poor water quality. Some species tolerate a wide range of conditions from good to poor, while others require good water quality (low levels of suspended solids and pollutants and a high level of dissolved oxygen). Trout and salmon require good water quality to maintain a viable population.

To correlate the presence or absence of specific benthic invertebrates to water quality conditions, Taccogna and Munro *(1995)* developed a *Field Identification and Pollution Tolerance Chart,* which groups common species of benthic invertebrates into three levels of pollution tolerance/intolerance. This reference is included in Appendix B of this report.

Several studies have been conducted recently on the present status of aquatic invertebrates in Bowker Creek. These include Lopez (1997) and Jancowski *(1996).* In both these papers, the most abundant species captured were Diptera larva. which include species such as flies, mosquitoes, black flies, and no-see-urns. These larvae are pollution tolerant organisms that can live in almost any quality of water (Taccogna and Munro *1995).* Other pollution tolerant species identified by Lopez and Jancowski include small freshwater leeches (Class Hirudinea),segmented worms (Class

Oligochaeta) often called earthworms, small freshwater snails (Class Gastropoda). flatworms (Class Tubellaria), and insects known as true bugs (Class Hemiptera). However, these two authors also found freshwater shrimp (Order Amphipoda) present in small numbers, beetle larva (Class Coleoptera), and crayfish (Class Decapoda), which are considered somewhat pollution tolerant organisms and are found only in fair or good water quality conditions. Finally, Lopez found one stone fly larva, which is an indicator of good water quality (Taccogna and Munro 1995). These results suggest that through the 1996/97 period, water quality conditions could be considered fair. bordering on good.

On July 21, 2000 benthic invertebrate spot sampling was undertaken by SHIP Environmental Consultants. It was observed that freshwater shrimp were distributed throughout the system in all open channels and in densities that appeared to be higher than those reported by Lopez and Jancowski. As well, the sow bug (Order Isopoda). another organism found in good or fair quality water. was identified (Taccogna and Munro 1995).

These combined results suggest that, at present, water quality could be considered fair. however the lack of pollution-sensitive species suggests that water quality conditions in Bowker Creek should not be classified as "good" at this time.

5.2.4 Discussion

When invertebrate populations in Bowker Creek are compared to both Douglas Creek and Colquitz River, it is surprising how similar the populations are. Similar pollution tolerant insects are found in Douglas and Bowker creeks, and pollution intolerant species are rarely found (see Appendix B in Haynes *et al* 1997 and Holmes 1999). **A** study comparing Douglas Creek to Colquitz River, found that Colquitz River had few pollution intolerant species as did Douglas Creek, however several species that are somewhat pollution tolerant were more abundant in Colquitz River than in Douglas Creek (see Appendix A in Sharma 2000). This difference in numbers of pollution tolerant invertebrate species in Colquitz River compared to both Douglas Creek and Bowker Creek suggests why naturally occurring salmon and trout populations are present in Colquitz River and not in Douglas and Bowker Creek. In 1997, Friends of Mount Douglas Park started stocking coho salmon *fry* in Douglas Creek, however except for the summer of 2000 (to date) there have been a number of fish kills in Douglas Creek. It is thought that these kills are a result of short duration deterioration of water quality such as was discussed in Section 4.5. It is anticipated that short-term lethal or sub-lethal water conditions also occur in Bowker Creek and likely with greater frequency and severity than Douglas Creek, simply because the Bowker Creek watershed is completely within commercial and residential developments. Hence, at

this time, it is not advisable to consider the introduction of fish into the Bowker Creek system. It was noted that three species of fish were captured in lower Bowker Creek (Section *5.2),* however these species (sculpins and stickleback) are tolerant of poor water conditions and can migrate to the marine environment to escape short-term unsuitable conditions in the stream, hence they may not truly reflect the present condition of water quality in Bowker Creek.

5.3 Channel and Streamside Vegetation Conditions

There are eight reaches within the Bowker Creek system which are not confined in pipe or conduit (see Section *2).* The upper two open reaches are wetland areas at the University of Victoria and Cedar Hill Golf Course, while the lower six reaches are open channels. All portions of the channel appear to have been modified. The most natural looking portions of the channel are in Oak Bay downstream of the Monteith Street culvert and in portions of Browning Park in Saanich. Within the six open channel sections, there are also small, scattered points that have a relatively natural appearance, however for the most part the channel has been confined to a narrow ditch (3–5 m wide) with steep, near vertical banks 2–3 m high. In many places, banks have been replaced by gabions, lock blocks, riprap, concrete, and cemented rock walls.

In Oak Bay, upstream of Monterey Avenue, Bowker Creek is virtually confined by either vertical rock walls or concrete walls. The only areas where channel banks exist are short sections of channel adjacent to the Oak Bay Recreation Centre parking lot from Bee Street to the Tennis Bubble and a section of channel immediately downstream of the Tennis Bubble. Therefore, for the most part, the channel through Oak Bay is completely stable and there are no concerns over erosion. However, the result of this bank protection work is that there is little opportunity for the development of stream side vegetation.

The open channel in Saanich from Trent Street to Richmond Road is a narrow ditch *2-3* m deep with a *3–5* m wide channel. The portion of channel adjacent to St. Patrick's school is the only area where there is evidence of bedload deposition; it is also the widest area of open channel. The existing banks are composed of mainly clays and silts, and appear relatively stable. Streamside vegetation varies. Downstream of Haultain Street vegetation cover is primarily small trees and shrubs, whereas near St. Patrick's School much of the streamside vegetation has been removed in order to improve stream discharge during high flow periods. Upstream of Haultain Street, the stream has complete canopy cover composed of conifers, maples, and willows which are growing on the BC Hydro property or on other adjacent private lands.

The next section of open channel is also in Saanich and extends from Newton Street to Pearl Street and cuts through the playing fields of Richmond Elementary School. The channel is 2-4 m wide and the banks are 2–3 m high. There is evidence of bank instability at some locations, however it is difficult to examine bank conditions due to the heavy growth of blackberry on the banks. There was, however. little evidence of bedload deposition in the channel. Stream bank vegetation now is primarily composed of blackberries and small willows, as it appears that large trees and shrubs were removed in portions of this channel in an attempt to increase the discharge capability of the channel during high flow conditions.

Within the open channel north of the Hillside Mall from Shelly Street to Knight Avenue, there are two distinct sections. The portion through Browning Park has the appearance of a relatively natural channel although there is evidence of some bank protection work. Downstream of Browning Park, the channel is mostly contained by gabions, lock blocks, and concrete retaining walls. The majority of bank throughout this open section appears stable and there is ample vegetation cover over the channel. One of the few areas lacking vegetation cover is at the Keats Street footbridge crossing.

5.3.1 Discussion

Most existing earthen stream banks are very steep (1:l slope), composed of clay tills. but appear to be relatively stable and resistant to erosion. However, the steepness of the banks does limit the amount and type of streamside vegetation that can develop. Hence, many typical riparian tree and shrub species that could potentially grow in this area are not present. One of the main problems may be due to the height of the bank (2–3 m), as riparian plants that do get a foothold on the bank tend to be too far above the water table to survive. The steep banks and thick blackberry patches also make much of the channel inaccessible to the general public.

The sections of the channel lined by lock block, gabion, or concrete walls are also difficult to access. These walls also make it virtually impossible for streamside vegetation to develop. However, in many locations trees established behind the gabions do provide suitable canopy cover for portions of the channel.

One of the chief concerns regarding vegetation is the presence of the introduced golden or yellow weeping willow (Salix babylonica). This willow has established itself along the length of the open channels in Bowker Creek. From an ecological perspective, this species is known to out-compete native willows and other species of plants and trees. The golden willow is also a major user of water compared to native willow species, because it has no mechanism to limit the transpiration of water from

its leaves on hot days. (Knighton, pers. comm). At many locations. large root mats up to 10 m long from individual willow trees have developed across the bed of the channel, to the point that the channel bed is composed of willow root mats and not stream bed material.

The continued existence of these willows is of concern to the authors for the following reasons:

- There is a significant removal of water from the stream by the willow. This could be a significant concern during warm low flow periods in the summer;
- The species of willow will be responsible for out competing many native tree and shrub species:
- The root mats eliminate the natural bed of the channel and the associated invertebrate production; and finally,
- There is the potential that these large root mats could be lifted off the bed of the channel during storm events and create a blockage to flood discharge.

5.4 Recreational Use of the Open Sections of Bowker Creek

5.4.1 Existing Recreational Use

From headwaters to mouth, Bowker Creek flows through only two designated parks: Browning Park in Saanich and Bowker Creek Park in Oak Bay. However, open sections of the channel can also be accessed by the public via a number of undeveloped adjacent properties. Most of these parcels of land are owned by public entities. Some are used so frequently that dirt paths have been worn into the ground cover vegetation. There is little use of the stream channel directly but the paths are used by people walking, jogging, and cycling for recreation and as non-motorized transportation corridors and are described below:

Stn 0+00 to 2+54 (District of Oak Bay)

Between the mouth of Bowker Creek and the Monteith Street culvert, the channel is contained in private property except for three undeveloped lots on the east side of Monteith Street owned by the District of Oak Bay. A dirt path through these lots beside the stream channel runs from Monteith Street for about 100 m, but is blocked by adjacent private residences and does not connect to any other roads. The creek is accessible from the path; its banks are shallow and fairly natural.

Together, the public property containing the next two open sections of the Bowker Creek channel provide an off-street walking route from Monteith Street to the Foul Bay Road and Fort Street/Cadboro Bay Road intersection.

Stn 5+62 to 9+86 (District of Oak Bay)

Between Monterey Avenue culvert and the Tennis Bubble culvert, the stream channel is contained entirely within public property. **A** concrete walkway beside the creek extends from the Tennis Bubble between the Jack Wallace Memorial Track and *Oak* Bay High School, along the Bowker Creek Walkway, across Hampshire Road, and through Bowker Creek Park to Monterey Avenue. From Monterey Avenue to Monteith Street, Bowker Creek is contained in a storm drain pipe under Fireman's Park. This section is heavily used by walkers and joggers and contains a baseball diamond. The only area where the banks are natural and accessible is on the north side of the channel near the Tennis Bubble. Elsewhere, the artificial banks are vertical. and surrounded by fences and railings.

Stn 10+62 to 12+88 (District of Oak Bay)

Between the Tennis Bubble culvert and the Cadboro Bay Road culvert, parking lots at Oak Bay Recreation Centre on the southwest and Oak Bay School parking lot on the northwest extend almost to the top of the banks of the Bowker Creek channel. A narrow dirt path runs between the Recreation Centre parking lot and the stream channel. Although the stream banks are not armoured. they are steep, making access difficult. Between Bee Street and Cadboro Bay Road, the channel flows between two commercial buildings. The banks are vertical cemented rock on both sides. A paved walkway runs along the east side of the channel. This walkway together with the ones beside the Tennis Bubble and through the previous section (Sta *5+62* to 9+86) form an off-street walking route from Monteith Street to the Foul Bay Road and Fort Street/Cadboro Bay Road intersection.

Stn 15-14 to 20+88 (District of Saanich)

A well-worn dirt path runs along the entire length of the Bowker Creek channel between the Trent Street culvert and the Richmond Road culvert. The properties crossed have several different owners:

- St. Patrick's Elementary School
- Royal Jubilee Hospital – northeast corner of property
- Bishop of Victoria – large undeveloped lot north of Adanac Street right-of-way
- District of Saanich – two undeveloped lots south of Haultain Street, plus portions of the Adanac Street and Trent Street rights-of-way
- BC Hydro – large lot north of Haultain Street

At the downstream end of this section by St. Patrick's School, the channel is fenced on both sides to prevent access. Upstream the channel is more accessible, especially north of Haultain Street on the BC Hydro property. This is a popular trail for walking and jogging.

In addition to the paths along open sections of the Bowker Creek channel, a walkway has been created over top of a culverted section of the stream on two lots owned by the City of Victoria. The Spirit *Garden* created by the North Jubilee Neighbourhood Association offers a pleasant footpath between Kings Road and Newton Streets just west of Richmond Road.

Stn 22+92 to 27+08 (District of Saanich)

It is possible to walk near the east side of the Bowker Creek channel between the Newton Street culvert and the Pearl Street culvert by cutting across the Richmond Elementary School playing fields and a strip of grass along Townley Street that appears to be owned by the housing complex on the west side of the channel. However, access to the creek is prevented by a chain-link fence at the top of the bank that surrounds the entire section of channel. A separate commuter path has not been established through these properties, perhaps because of a fence at the northwest edge of the school property and the proximity of a sidewalk along Townley Street.

Stn 40+08 to 46+50 (District of Saanich)

From the Shelley Street culvert to McRae Avenue, Bowker Creek is contained in private property except for one lot immediately upstream from Keats Street owned by District of Saanich and portions of road rights-of-way on Shelley, Keats, and Wordsworth streets. Footbridges have been constructed in the Keats Street and Wordsworth Street rights-of-way. Limited access to the channel is available near the Wordsworth Street Bridge. Browning Park is located upstream of McRae Avenue and extends to the Knight Avenue culvert. In some parts of the park, paths run along both sides of the creek, connected by two footbridges. The banks are often steep, but access to the edge of the channel is possible in many places.

Tributary 1: Upstream of Stn 101+62 (District of Saanich)

Upstream of the Cedar Hill Road culvert to the headwaters of this Bowker Creek tributary, the channel flows through the Cedar Hill Recreation Centre and Cedar Hill Golf Course. Portions of the channel are wetlands. Except for a couple of long culverts in the golf course, the stream is accessible. Walkers and joggers do not follow the

channel; instead, they use a popular chip trail around the perimeter of the golf course that crosses the channel with footbridges and short culverts.

Tributary 2: Upstream of Gordon Head Road Culvert (District of Oak Bay)

Upstream of Gordon Head Road culvert, the property is owned by the University of Victoria. There are no paths following this Bowker Creek tributary channel per *se.* as travel by foot beside the Gordon Head Road ditch is probably influenced more by the presence of the road than by the creek channel. Technically, the creek is accessible throughout this section, but the wetland vegetation is dense and often uninviting. It does, however, provide high-quality habitat for birds and amphibians (Westland 2000). The heavily used Alumni Chip Trail circling the campus crosses the wetter areas with a boardwalk.

5.4.2 Stream Rehabilitation Initiatives

For decades, three municipalities have used Bowker Creek as a conduit for storm water runoff. which has disrupted the natural flow regime, compromised water quality. and destroyed stream habitat. In recent years, many community groups and municipal planners are advocating the preservation of open sections of Bowker Creek and exploring the feasibility of creating a greenway alongside the stream. and rehabilitating portions of the stream channel to improve biodiversity. Among these groups and initiatives are the following:

Provincial Capital Commission

As part of its Community Greenways strategy, the Provincial Capital Commission (PCC) developed a Greenways Program to promote the creation of greenway corridors throughout the Capital Improvement District, which includes the Bowker Creek watershed. The greenways link parks and other public open green and blue spaces to each other for passage by wildlife and humans using non-motorized transportation, such as walking and cycling. The PCC has also established a grant program to fund projects that promote and establish greenways in the Capital Region.

Capital Regional District

In conjunction with the PCC, the Capital Regional District (CRD) initiated the Regional Green/Blue Spaces Strategy as "a vision of cooperative stewardship" (CRD Parks and PCC 1997). The goals of the Strategy are to encourage the creation of a regional system that will maintain or enhance species diversity in a variety of habitats, protect or restore sensitive ecosystems, and provide people with opportunities to enjoy

the natural world. Bowker Creek is identified as a *Stream and Wetland Stewardship Green/Blueway* in the Green/Blue Spaces Strategy document.

Shelboume Local Area Plan

The Shelboume Local Area Plan is part of the Saanich Official Community Plan. It contains policies relevant to the neighbourhood level of administration and provides a "reference for Saanich Council decisions on development proposals and capital works" (District of Saanich 1998).

According to the Local Area Plan, the "primary function [of Bowker Creek] is as a major storm drain for Shelboume." Yet, it also recognizes that Bowker Creek is "important because it can support native vegetation communities. provide a link between land and the ocean, and provide opportunities for outdoor recreation." Two environmental policies (5.4 and 5.5) in the Plan make specific reference to Bowker Creek. Policy 5.4 states that the municipality will "seek opportunities to restore and daylight sections of Bowker Creek." Policy 5.5 "supports community initiatives.. .for stream stewardship and environmental education programs relating to Bowker Creek."

Areas of park expansion and potential park creation in the Bowker Creek corridor are also outlined in the Plan. Six lots on the west side of Shelboume Street adjacent to Browning Park that are currently used for single-family residences have been acquired by the District of Saanich and zoned Park. When annexed to Browning Park, the lots will provide additional green space and increase the visibility of the park on Shelboume Street. A portion of the BC Hydro property (Between Haultain and Kings streets) and a lot owned by the Bishop of Victoria on Adanac Street have been identified as potential parkland.

At the time of writing (Sept 2000), Saanich planners had nearly completed a greed/blue spaces strategy document that "customizes" the Regional Green/Blue Spaces Strategy for the municipality. Like its regional counterpart it does not include specific concept plans, but rather identifies the steps required to facilitate public access to green spaces, establish walkways,, and enhance plant and animal habitat. (Topp, pers. comm). Following acceptance of the strategy by the Saanich Council, the feasibility of developing a greenway along the open sections of Bowker Creek will be investigated.

Capital Health Region

About 50 m of the Bowker Creek channel is contained in the northeast corner of the Royal Jubilee Hospital grounds near the new cancer clinic building. The Capital Health Region Planning and Construction Department hired a fisheries habitat biologist (Craig Barlow, Applied Ecological Solutions) to create a concept plan for possible rehabilitation of the part of the stream channel. The consultant proposed additional water quality treatment structures, rock weirs to create habitat diversity in the stream channel, and additional riparian plantings. The Capital Health Region is considering their options for work in this area and expect to be part of the anticipated Bowker Creek integrated watershed management planning process (Friedmann, pers. comm.).

Friends of Bowker Creek Society

The Friends of Bowker Creek Society is a non-profit stream stewardship group formed in 1996. The group has four main objectives:

- Promote the protection, enhancement, and restoration of Bowker Creek and adjacent green spaces;
- Provide a focus for community-based action on the environment;
- Provide educational opportunities and raise awareness of local ecosystem and watershed processes; and
- Encourage the development of a continuous green space corridor along Bowker Creek, connecting the municipalities of Saanich, Victoria, and Oak Bay.

To achieve these goals, the group has organized an annual clean-up day to remove garbage from the channel and has conducted numerous walking tours of the open sections of the creek. They have received funding for projects such as planting native plant species on a section of damaged stream bank and producing an educational brochure that was distributed to residents and businesses located in the Bowker Creek watershed. The group has an Internet web site (www.members.home.net/chrisdate/bowker.htm) that includes information on the history of the creek, species lists, and activities of the group.

In 1998199, the Habitat Acquisition Trust Foundation (established in 1996 by the Victoria Natural History Society) and Ecotrust Canada Mapping Office created a prototype Geographic Information System (GIS) database to demonstrate the usefulness of GIS databases to conservation organizations and municipalities. Bowker Creek was selected as the subject of the prototype in part because the Friends of

Bowker Creek Society intended to continue mapping work after the completion of the demonstration project.

Camosun Community Association

The Camosun Community Association (CCA), a registered society, was formed in 1997 by Saanich residents living east of Shelboume Street and south of Knight Avenue and Mt. Tolmie Park to work together to influence decision makers on issues of concern within the neighbourhood. Issues addressed by the group include traffic calming, municipal infrastructure, Vancouver Island Cancer Centre construction, Bike-to-Work Week, on-street parking, restoration of the Camosun College Young Building, and the Saanich Greenways plan.

In August 2000, The CCA received a grant from the PCC Greenways programs for a project titled *Supporting a Regional Vision for the Bowker Creek Corridor Community Awareness and Extension Tools.* The purpose of the project is to develop a number of community awareness materials that emphasize the connections between the public green spaces available in the municipalities of Saanich. Oak Bay. and Victoria as well as the connections between stream stewardship projects related to Bowker Creek undertaken by various governmental and non-governmental organizations. (Graeme, pers. comm.)

5.5 Hydraulic Conditions

This section discusses the hydraulic conditions in the major reaches of the creek and provides limited recommendations. Figures 3 through 9 illustrate the locations of the items discussed.

Oak Bay

Within Oak Bay, critical hydraulic conditions occur at Firemans Park where the creek is enclosed in a 300m long by 2100mm diameter storm drain. The capacity unsurcharged is believed to be equivalent to the 5 to 10 year return period which is normally inadequate by modem design standards for a major drainage facility. However we understand property flooding was nominal when the drain was surcharged (November 1990) and therefore a reduced criteria may be acceptable. It would be a costly section of pipe to replace, therefore any efforts in the upstream watershed to maintain or reduce flows through the use of stormwater detention would be beneficial. In the meantime the District of Oak Bay may wish to formalize the overflow route and protect any property subject to flooding.

Within Bowker Creek Park the capacity appears to be adequate and the design of the creekside park allows for surcharge and storage without property damage. Immediately upstream from the Park, where the creek traverses the Oak Bay High School yard the north bank has become heavily overgrown with willows and it may eventually cause sufficient restriction to effect the Tennis Bubble and the Recreation Centre. **A** clearing program should be planned that results in an appropriate mix of streamside vegetation. The other significant open channel reach, between the Tennis Bubble and Bee Street, is also overgrown and would contribute to high flood conditions through the Foul Bay Road/ Cadboro Bay Road culvert. In this section care will be required to design a clearing program that will maintain channel capacity without destabilizing the tree covered banks. Tall trees along the bank in this reach are not desirable due to the risk of bank failure should a tree be uprooted during a major runoff event. The Oak Bay staff would like to construct an engineered channel along this section to help ensure the security of the Recreation Centre.

City of Victoria

The only hydraulic condition of concern in Victoria is the inlet to the storm drain at Trent Street. Since it has flooded approximately five times in the last 30 years, it clearly does not have 25 year flood capacity which should be the minimum criteria where property damage results, as is the case at this site. (The basement floor elevations at St. Patrick's School and at 2456 Trent Street will never be fully protected as they are too low, but as there is no safe overland route away from the area a major storm could have serious consequences for the other surrounding properties.) This is a complicated situation because hydraulic improvements may worsen the flooding in Oak Bay. A full analysis, with benefits and costs fully accounted, is the only way to determine the correct structural solution. This work should also examine whether land purchase and storrnwater storage creation would produce an economical solution. The status quo of no action may also be the correct solution but the municipality should be prepared to pay for flood damage on an intermittent and continuing basis. For discussion purposes if the expected average annual damage cost is $5000 (which is equivalent to $50,000 damage during a 10 year event or $125,000 during a 25 year event) the present value is approximately $100.000 to $150,000. Assuming all damage is eliminated by the improvements and there is no ongoing maintenance associated with the works, the present value is the largest sum that could be spent to eliminate flooding in this reach while maintaining a benefit/cost ratio of 1.0 or more. In this example, paying for flood damage is therefore more economical unless improvements can be made for less then $100,000 to $150,000.

District of Saanich

Figure 5 illustrates a location for potential floodplain widening on vacant property at the east end of the Adanac Street right of way. If 1.5 m depth of flood storage could be developed in this area the volume would be approximately 8000 m^3, or approximately one-half the potential storage on Uvic property at Gordon Head Road. This is a relatively small volume compared to the storm runoff volume but would nevertheless improve conditions by a small amount. The BC Hydro reserve, north of Haultain Street ***(Figure* 5)** may also be suitable for floodplain widening but the bank appears to be higher in this reach and excavation volumes would be greater. Also a well established tree canopy exists along the creek in this property, thus making it more difficult to establish floodplain widening. Despite the perceived need to retain the tree canopy, it may still be possible to create 8000 m^3 of storage assuming a storage depth of 1.5 m. Other potential floodplain widening sites around Richmond Elementary School and Townley Street ***(Figures* 5 *and 6)*** could provide perhaps *2* m of storage for a volume of 11,000 m^3; again a relatively small volume. but significant. The costs for such a facility would be mainly excavation and landscaping. Small potential floodplain widening sites exist on the Wordsworth Street right of way and within Browning Park ***(Figure* 7).** A new detention pond was constructed on the Cedar Hill Golf Course in 1999. It provides 1000 m^3 of storage ***(Figure 8).*** The potential 16,000 m^3 detention pond on Uvic property near Gordon Head Road is shown on ***Figure 9.***

The maintenance of hydraulic capacity in the man-made open-channel reaches is a continuing problem. Following channel clearing the gradual natural revegetation of the channel banks with plants that eventually reduce channel capacity should be evaluated and if possible an approach should be adopted that allows for establishment of an optimum cross section and replanting with appropriate species. Combined with regular maintenance this approach would ensure adequate capacity at all times, not just in the period following intermittent bank clearing.

All Municipalities

While water quality has apparently improved over recent years it has been largely due to efforts to control sanitary sewer cross connections and spills. For this improvement to continue the quality of urban stormwater needs to be addressed. Use of oil/grit separators, grass swales or small on site wetlands will greatly improve water quality runoff from pavements. The municipalities should, as a minimum, require new developments to provide measures that will improve stormwater quality. Efforts should also be made to improve pollutant trapping and removal at all high traffic areas where pollutant loading is highest.

Low Summer Flows

There was a consistent low flow in Bowker Creek over the summer of 2000. It was somewhat of a surprise that flows were not reduced to a trickle or to areas of standing water, but instead a flow between 0.1 m^3/s and 0.2 m^3/s was maintained over the summer. The source of this water is existing seepage and groundwater. There are virtually no surface flow sources.

6.0 SUMMARY OF ISSUES AND REMEDIATION OPTIONS

The following issues and remediation options should be considered in any subsequent planning process for the Bowker Creek watershed.

- Maintain and rehabilitate the open channel portions of Bowker Creek.

  There is a strong desire by the community at large to create a linear park along the open portions of Bowker Creek. As well, it is possible to increase the existing bio-diversity of the stream and riparian zone. Improved species diversity (native vegetation, benthic invertebrates, birds, and small mammals) will increase the value of the linear park.

- There is little likelihood in the foreseeable future of successfully introducing a sustainable salmon or trout population in Bowker Creek.

  There are a number of potentially lethal or sub-lethal conditions that will make it very difficult to sustain salmon or trout populations. Sudden increases in water temperature and level of dissolved nutrients, and decreases in dissolved oxygen will result from short duration rainfall events particularly in the summer and fall.

  As well, as noted by Norris (1988) and others, there are a number of features present in the channel that would make fish passage for salmon from the ocean difficult, if not impossible. The extreme length of the culverts (200–300 m) combined with several sharp corners such as are found at Fort Street (Figure 4) create serious obstructions. As well, there are several 1.0-m high weirs in the Oak Bay open channels that would also prevent fish passage

- There is no strong argument to consider daylighting any additional portions of Bowker Creek.

  The only area which could be feasibly opened at this time is the playing field between Monterey and Monteith streets in Oak Bay. All other areas would require excavation of streets or the purchase of private property adjoining both sides of the

channel. As well, because there is little chance of ever establishing sustainable salmon or trout populations there is no need for additional stream habitat. From a recreational point of view, the playing field at Monterey Street or the Spirit Garden at Newton Street already provide a variety of recreation and aesthetic features that may be as valuable as an open channel. It is more important at this time to consider the rehabilitation of the existing portions of open channel rather than to pursue the daylighting of additional portions of the channel.

- Development of improvements in water quality should continue.

  A primary concern is the protection of the marine receiving environment. Significant reductions in existing coliform levels have occurred as a result of the elimination of sewer/storm drain cross connections. This reduces risk to the public. The creek supports a variety of moderately pollution tolerant invertebrates. Continued work at the elimination of pollutants in the storm water will allow these species to maintain sustainable populations. Improved benthic invertebrate populations will provide additional food sources for bird populations.

- Many engineering requirements for stormwater management and features considered desirable in linear greenway are compatible.

  Development of stormwater storage with reduced bank heights will allow for improved access to the stream channel for people and the opportunity to establish a more natural riparian vegetation and tree cover along the proposed greenway.

  Subject to positive feasibility studies, existing open land adjacent to Bowker Creek should be restructured to facilitate additional stormwater storage. The lands identified include:

  - Royal Jubilee Hospital, Bishop of Victoria, Dean and Adanac rights-of-way (Figure **7)**
  - BC Hydro Reserve (Figure 5)
  - Richmond Elementary (Figure 5)
  - Townley Street (Figure 5)
  - Wordsworth Street right-of-way (Figure **7)**
  - Browing Park (Figure 7)
  - Cedar Hill Golf Course (Figure ***8)***
  - University of Victoria (Figure ***9)***

In all cases, except for the Cedar Hill Golf Course, and the University of Victoria. it is possible to reduce the existing bank height to less than 1.0 m above the bed of the existing channel to increase storm water storage.

- The existing Bowker Creek base flow channel should not be widened.

  Aside from creating floodplain water storage areas adjacent to the Bowker Creek channel, the existing Bowker Creek channel should not be modified by creating ponds or wetland areas, as these will only increase the exposure of the water surface to sunlight, thus risking increases in water temperature and reductions in stream flow and oxygen levels. As well, wetland areas may increase waterfowl use, which could result in an increase of coliform levels and possibly the potential for an increase in mosquito populations.

- Existing open land adjacent to Bowker Creek should be designated as linear park or greenway.

  All portions of the open channels of Bowker Creek adjacent to vacant land are areas where people walk. They are not all designated as parks; many are just vacant portions of private land. There is a strong desire by local community groups and a willingness by Saanich and Oak Bay to consider the development of a linear park or greenway along Bowker Creek. This would include all land proposed to be restructured for storm water storage, plus additional lands needed to provide linear connections. Presently occupied land that would be desirable and feasible to include in a greenspace plan should also be identified. It is recognized that some land that may not presently be available for linear park should be identified so if the opportunity arises in the future, it could be acquired.

- Existing stream banks should be restructured to facilitate the development of native riparian vegetation and access for people.

  It is important to establish both riparian and eventually canopy cover over the existing channel. Without well-established vegetation cover, there is a risk of subjecting the channel to increases in both water temperature and rates of evaporation.

  In areas where it is not planned to create storm water storage, it is still desirable to create low terraces (less than 1.0 m) above the stream bed and at a minimum of 1-2 m wide to provide planting areas for native riparian vegetation. As well, to improve access to the channel for the public, stream banks should be sloped back to at least *2*:1 slopes. It is not necessary to provide access along the channel itself,

however there is a need to maintain a visual connection between walking trails and the stream channels.

Moderately dense plantings of the following (mostly) native species on the banks and in the riparian zone would soon provide shade and some structure for the stream channel:

Trees:
big-leaf maple *(Acer macrophyllum)*
Scouler's willow *(Salix scouleriana)*
Hooker's willow *(Salix hookeriana)*
grand fir *(Abies grandis)*
black cottonwood *(Populus trichocarpa)*
Oregon ash *(Fraxinus latifolia)*
Pacific willow *(Salix lucida)*
Douglas-fir *(Tseudotsuga manziesii)*
red-cedar *(Thuja plicata)*

Shrubs:
Pacific ninebark *(Physocarpus capitatus)*
hardhack *(Spiraea douglasii)*
chokecherry *(Prunus virginiana)*
Geyer's willow *(Salix geyeriana)*
red-osier dogwood *(Cornus siolonifera)*
wolf willow *(Eleagnus commutata)*
mountain ash *(Sorbus sitchensis)*
Sitka willow *(Safix sitchensis)*

If the bank heights are reduced to 1.0 m or less above the stream bed, all of the tree and shrub species noted above would be viable. However, if the top of bank is to remain over 1.0 m above the stream bed, then the cottonwood and all willow species could not be used, and only the wolf willow and chokecherry could be utilized (Knighton, pers. comm.).

A re-vegetation plan should emphasize the introduction of native species. Implicit in this is the need for removal of the golden weeping willow *(Salix babylonica)* and Himalayan blackberry bushes. Removal of these introduced species and establishment of native species will require long-term maintenance of the linear park and stream channel.

- Development of water storage or retention techniques to control and treat initial or "first flush" discharges to the storm drainage system. Continue to improve Bowker Creek water quality through a variety of treatment techniques.

Over the long term, consideration should be given to water storage in parking lots and roads. Any way to reduce initial discharges to Bowker Creek during small summer rainfall events will protect water quality in Bowker Creek. One possibility would be to store water in road gutters or perhaps water could be diverted to the sewage system. During large storm events, it is recognized that it is likely very difficult to increase water storage on roads and parking lots thus the potential floodplain widening will help in this regard.

Elimination of sewage/storm drain cross connections has contributed to significant reductions in coliform levels in Bowker Creek. Installation and maintenance of oil/grit separators and replacement over time of existing catch basins with more efficient designs will also significantly improve water quality in Bowker Creek and in the marine receiving environment as well.

- Monitor Bowker Creek water quality to assess whether fish can be supported.

  It was noted in this report that Bowker Creek will not be able to sustain fish populations in the foreseeable future and therefore fish introductions were not recommended. It is likely that this will not be accepted by some individuals or groups.

  In order to better assess whether water quality is adequate to support fish, it is suggested that two continuous water quality monitoring stations be established. Probable locations could be Browning Park and in the vicinity of St. Patrick's School. At both sites, there should be continuous monitoring of the following parameters:

  - Dissolved oxygen,
  - Water temperature,
  - Conductivity,
  - PH,and
  - Turbidity/suspended solids (possibly).

  With this sampling program, sudden changes in water quality can be documented and as water quality treatment improves, improvements in stream conditions will be documented. This water flow/water quality assessment could be funded jointly by the University of Victoria, Camosun college, the three municipalities, and interested community groups. Combined with this could be yearly aquatic insect sampling at fixed sampling locations. This would be done to see whether changes in water quality were reflected in invertebrate populations.

  As well, at least one stream discharge gauge should be established. Likely the best site would be at one of the concrete lined channels in Oak Bay.

Recommendation

It is recommended that the CRD, in consultation with municipal government, community groups and others, guide the formation of a Watershed Management Forum for the Bowker Creek watershed. The objective of the Forum would be the development of a Watershed Management Plan for the Bowker Creek watershed.

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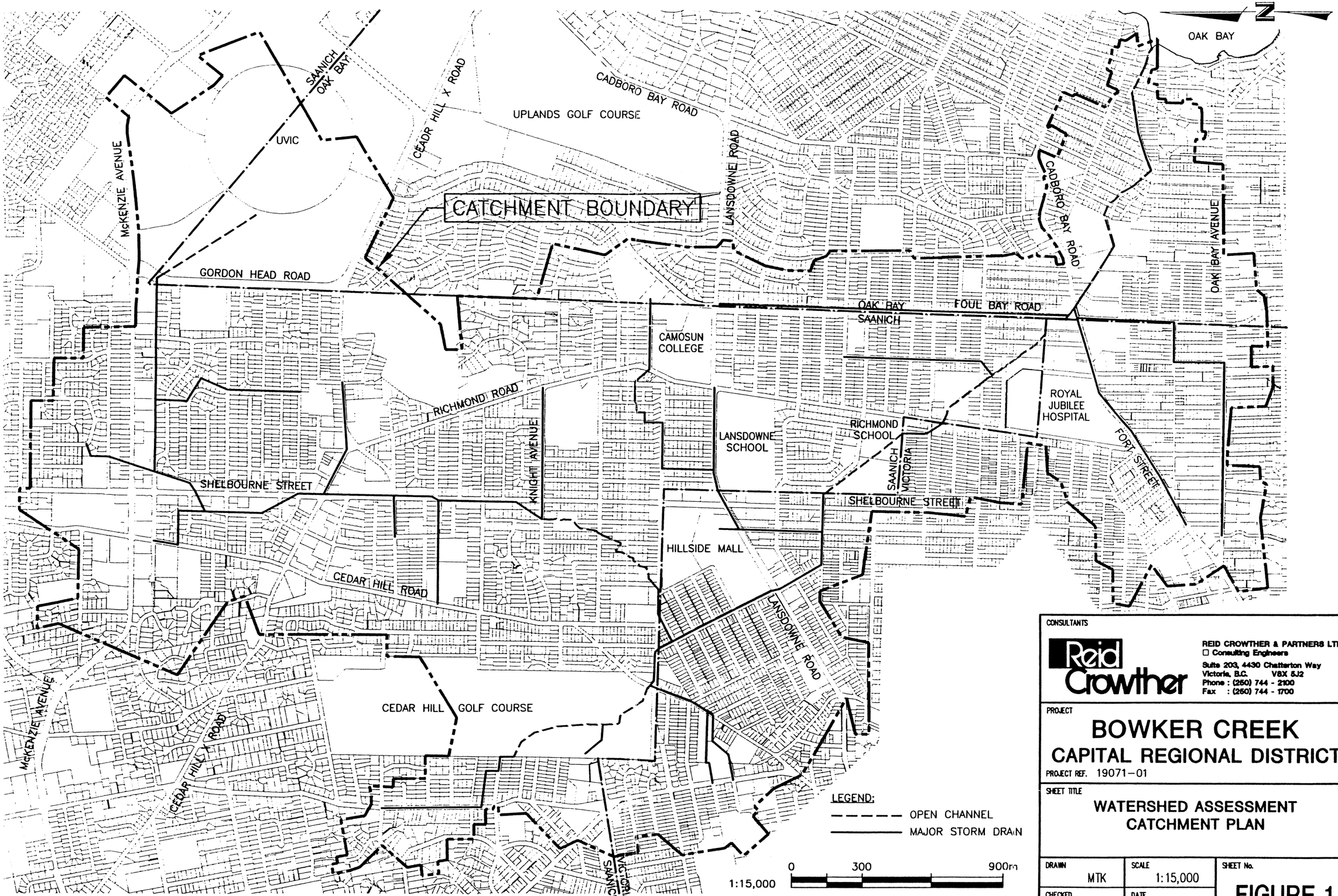
Friedmann, Norma. Planning and Construction Department, Capital Health Region
Graeme, Ian. Director of Friends of Bowker Creek Society
Knighton, Charles. Professional Horticulturist, Charles Knighton & Associates

FIGURES



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PROJECT

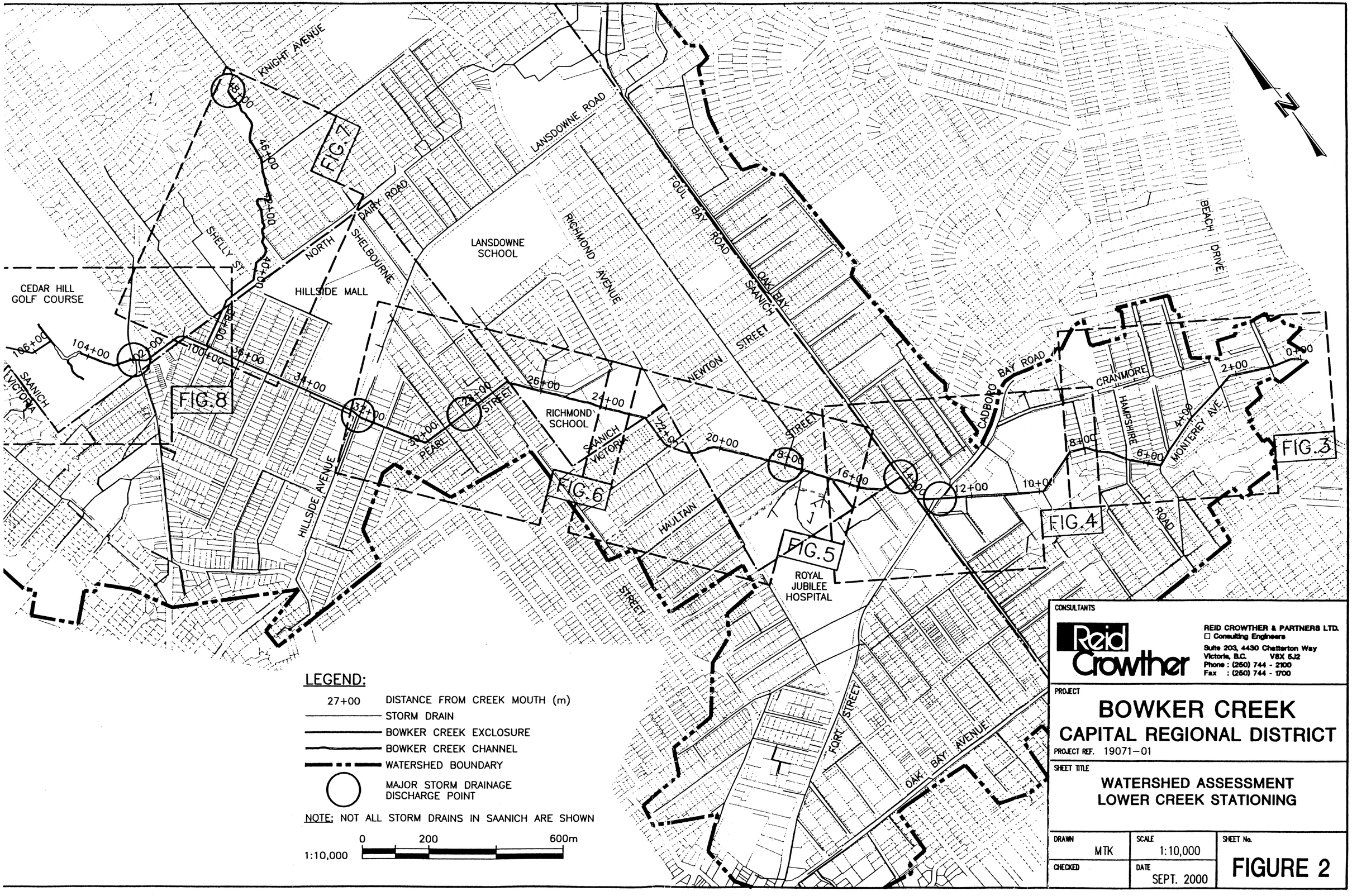
BOWKER CREEK
CAPITAL REGIONAL DISTRICT

PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT CATCHMENT PLAN

DRAWN	SCALE	SHEET No.
MTK	1:15,000	FIGURE 1
CHECKED	DATE SEPT. 2000	



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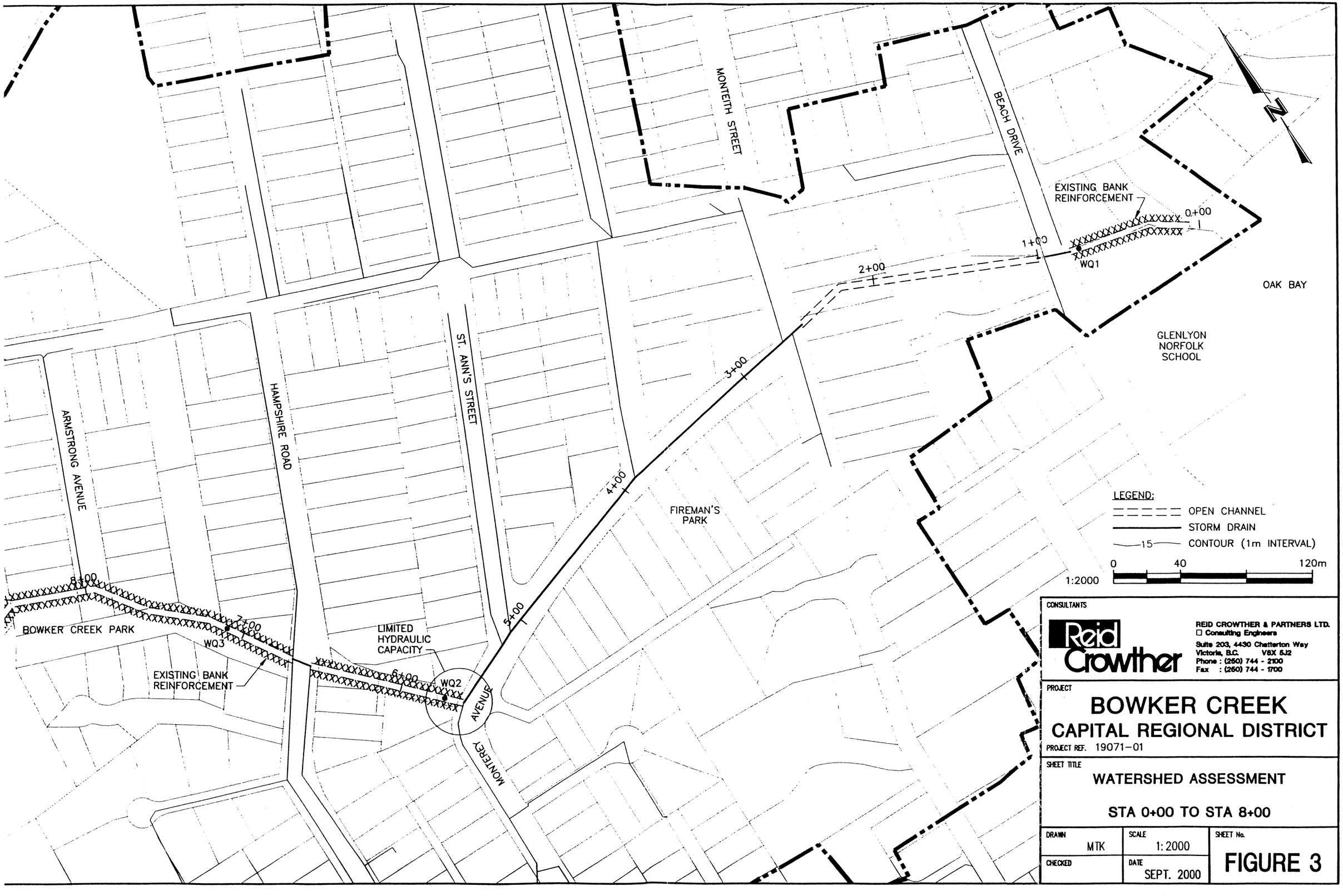
PROJECT
BOWKER CREEK
CAPITAL REGIONAL DISTRICT
PROJECT REF. 19071-01

SHEET TITLE
WATERSHED ASSESSMENT
LOWER CREEK STATIONING

DRAWN	SCALE	SHEET No.
MTK	1:10,000	FIGURE 2
CHECKED	DATE SEPT. 2000	



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PROJECT

BOWKER CREEK
CAPITAL REGIONAL DISTRICT

PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 0+00 TO STA 8+00

DRAWN	SCALE	SHEET No.
MTK	1: 2000	FIGURE 3
CHECKED	DATE SEPT. 2000	

AREA SUBJECT TO FLOODING
(SHOWN SCHEMATICALLY ONLY)

POTENTIAL DIVERSION
AWAY FROM SCHOOL

PLAYFIELD

16+00

15+00

ST.PATRICK'S
ELEMENTARY
SCHOOL

LIMITED
INLET
CAPACITY

14+00

MINOR
BANK
EROSION

TRENT STREET

CADBORO BAY ROAD

BEE STREET

13+00

EXISTING BANK
REINFORCEMENT

LIMITED CHANNEL CAPACITY

12+00

11+00

WQ5

TENNIS
BUBBLE

WQ6

10+00

WQ4

NORTH BANK OVERGROWN

OAK BAY
HIGH SCHOOL

9+00

8+00

EXISTING BANK
REINFORCEMENT

OAK BAY
RECREATION CENTRE

N

LEGEND:

- OPEN CHANNEL
- STORM DRAIN
- 15 CONTOUR (1m INTERVAL)

0 40 120m

1:2000

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PROJECT

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CAPITAL REGIONAL DISTRICT

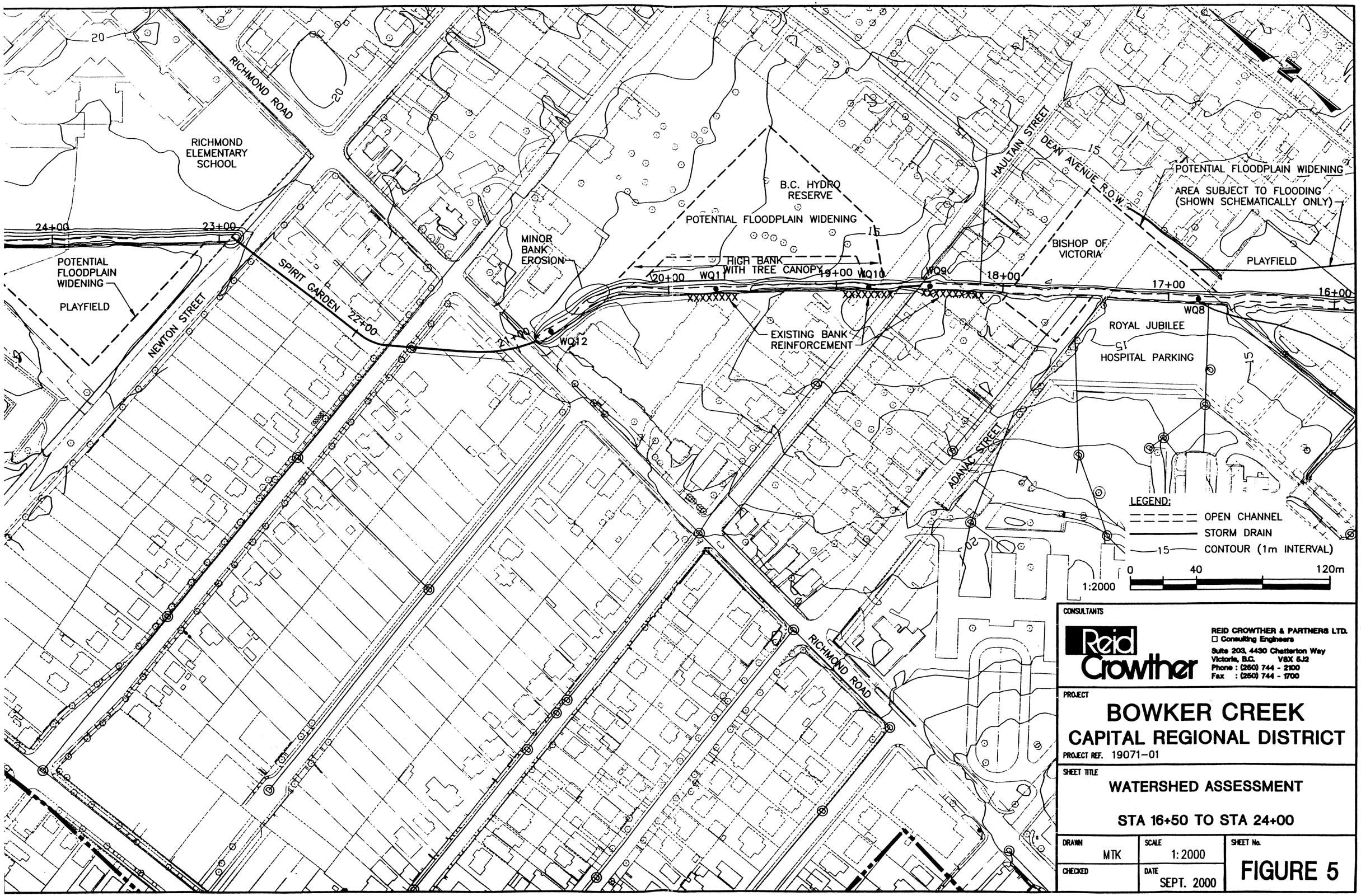
PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 8+00 TO STA STA 16+50

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 4
CHECKED	DATE SEPT. 2000	



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PROJECT

BOWKER CREEK
CAPITAL REGIONAL DISTRICT

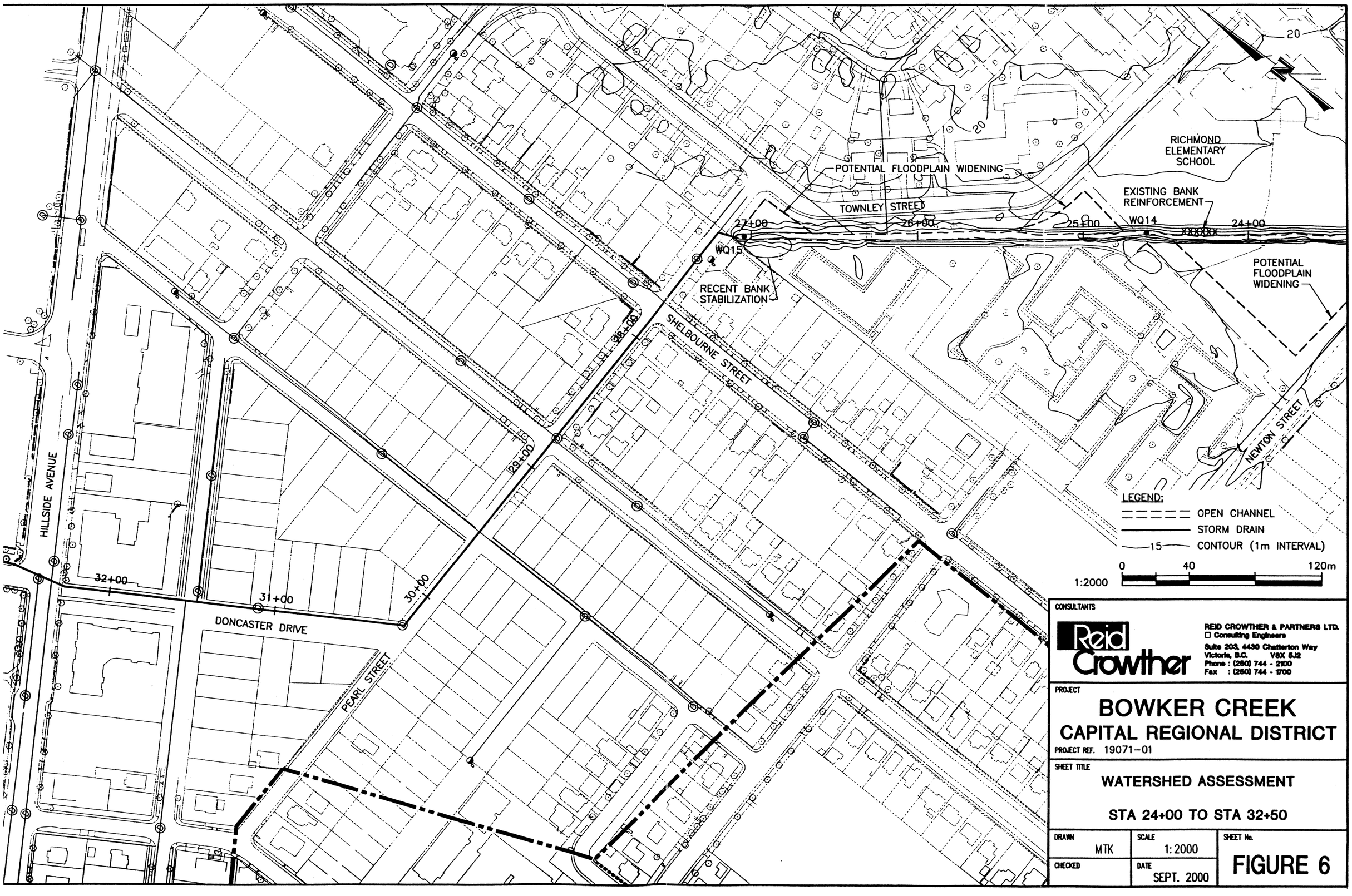
PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 16+50 TO STA 24+00

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 5
CHECKED	DATE SEPT. 2000	



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PROJECT

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CAPITAL REGIONAL DISTRICT

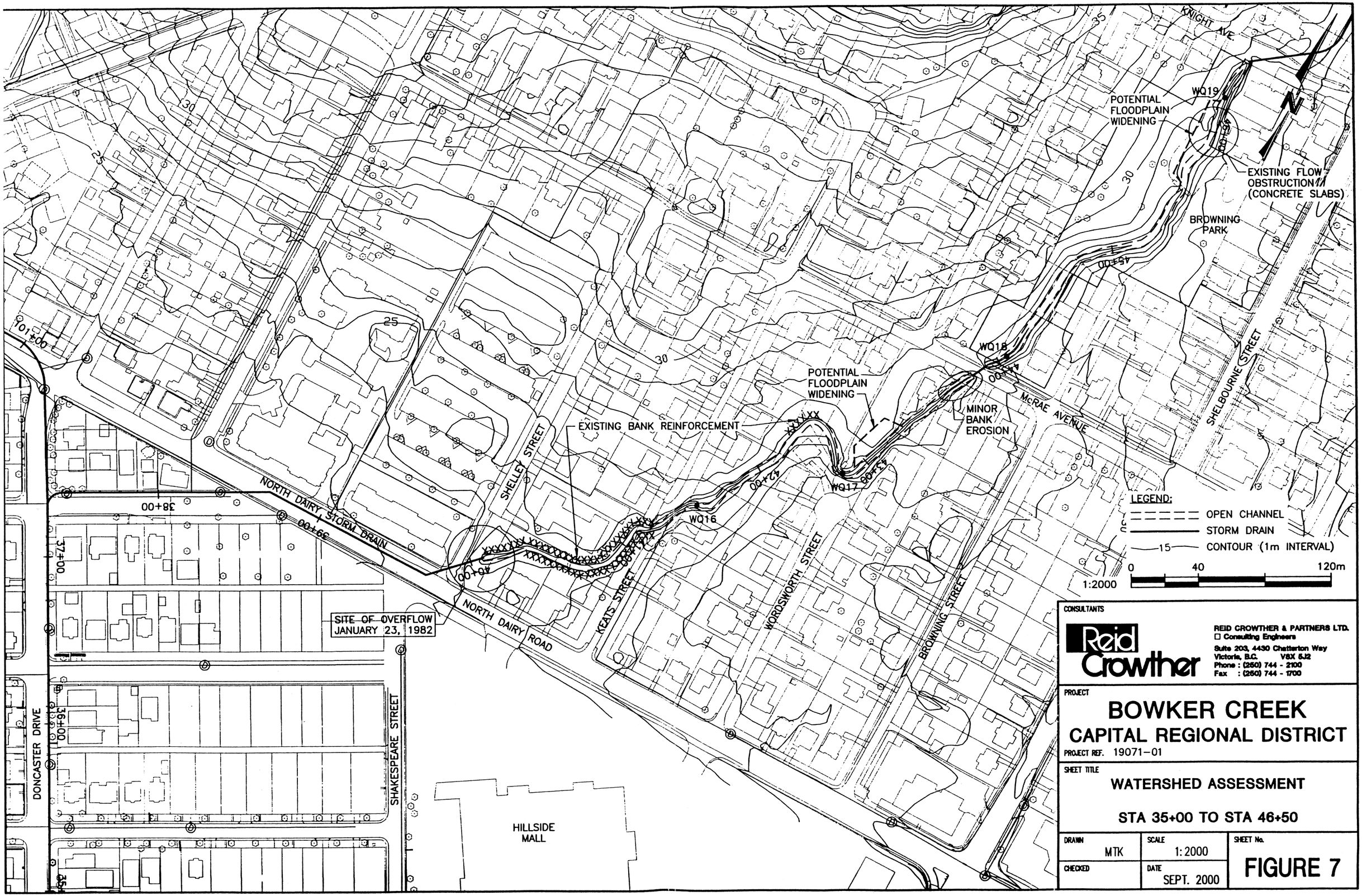
PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 24+00 TO STA 32+50

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 6
CHECKED	DATE	
	SEPT. 2000	



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PROJECT

BOWKER CREEK
CAPITAL REGIONAL DISTRICT

PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 35+00 TO STA 46+50

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 7
CHECKED	DATE SEPT. 2000	

CEDAR HILL GOLF COURSE

EXISTING 1000m³ DETENSION POND (CONSTRUCTED 1999)

WQ20

CEDAR HILL RECREATION CENTRE

106+85

106+00

105+99

104+00

103+00

102+00

101+00

38+00

37+00

DONCASTER DRIVE

NORTH DAIRY ROAD

CEDAR HILL ROAD

FINLAYSON STREET

35

30

25

N

LEGEND:

OPEN CHANNEL

STORM DRAIN

15 CONTOUR (1m INTERVAL)

0 40 120m

1:2000

CONSULTANTS

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PROJECT

BOWKER CREEK
CAPITAL REGIONAL DISTRICT

PROJECT REF. 19071-01

SHEET TITLE

WATERSHED ASSESSMENT

STA 100+00 TO STA 107+00

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 8
CHECKED	DATE SEPT. 2000	

CENTENNIAL STADIUM

UNIVERISTY OF VICTORIA

55

55

UNIVERISTY DRIVE

50

WATERSHED BOUNDARY

25 YEAR POND OUTLINE

POTENTIAL
DETENTION
POND

45

WQ21

GORDON HEAD ROAD

McKENZIE AVENUE

JADE PLACE

45

EMERY PLACE

MIDGARD STREET

LEGEND:

OPEN CHANNEL

STORM DRAIN

15 CONTOUR (1m INTERVAL)

0 40 120m

1:2000

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PROJECT

BOWKER CREEK
CAPITAL REGIONAL DISTRICT

PROJECT REF. 19071-01

SHEET TITLE

POTENTIAL DETENTION POND AT UNIVERSITY OF VICTORIA

DRAWN	SCALE	SHEET No.
MTK	1:2000	FIGURE 9
CHECKED	DATE SEPT. 2000	

APPENDIX A

INVENTORY OF OPE SECTIONS OF BOWKER CREEK

APPENDIX A
INVENTORY OF OPEN SECTIONS OF BOWKER CREEK

Information regarding the eight open sections of Bowker Creek was obtained from previous knowledge of the stream channel and a site visit on July **21,** 2000. For the non-technical reader, several terms used in these summaries are defined below. Definitions are taken from the *Fisheries Habitat Inventory and Information Program Stream Survey Field Guide* (prepared by the Canadian Department of Fisheries and Oceans and BC Ministry of Environment and Parks, **1987):**

crown closure:	streamside vegetation that projects over the stream channel and that is greater than 1 m above the water surface.
confinement:	the degree to which the river channel is limited in its lateral movement by terraces or valley walls.
entrenched:	a stream bank that is in continuous contact with valley walls or terraces due to downcutting.
unstable bank:	that portion of the stream bank which exhibits signs of failure (e.g. erosion, slumping, trampling).

To provide an historical perspective for conditions in the Bowker Creek channel, data collected in a previous aquatic biophysical survey are also included in the summaries (Noms 1988).

Location: Stn 0+00 to 2+54 (District of Oak Bay)
Between outlet and Monteith Street culvert

- **Water Quality Sample Sites:** SHIP site 1, CRD station no. **3**16-1
- **Land Status:**
  single- and multi-family residential
  three lots owned by District of Oak Bay are undeveloped
- **Recreation:** some limited use for walking as only the upper portion downstream of Monteith Street is not on private property
- **Road Crossings:** culvert under Beach Drive
- **Crown Closure:**
  Norris **(1988): 30%,** mostly upper half of reach
- **Confinement:**
  Noms **(1988):** entrenched
  SHIP.(2000): stream banks tend to be **2-3** m high except for the portion immediately downstream of Monteith Street
- **Bank Composition:**
  Noms (1**988)** comments: artificial banks downstream of Beach Drive (concrete, concrete bags. and cemented rocks); 50% artificial banks upstream of Beach Drive
  SHIP **(2000):** no change apparent

- Bank Stability:
  Norris (1988): 10% unstable
  SHIP (2000): no change
- Comments: Norris (1988) found three species in this in this section: prickly sculpin, coast range sculpin, and three-spine stickleback

Location: Stn 5+62 to 9+86 (District of Oak Bay)
Between Monterey Avenue culvert and Tennis Bubble culvert

- Water Quality Sample Sites: SHIP sites 2-4
- Land Status:
  - Bowker Creek Park (south of Hampshire Road)
  - Bowker Creek Walkway (north of Hampshire Road)
    Oak Bay High School
- Recreation: Bowker Creek Park and Walkway paths are heavily used by walkers and joggers
- Road Crossings: culvert under Hampshire Road
- Crown Closure:
  Norris (1988): 30%
  SHIP (2000): no change since 1988
- Confinement:
  Noms (1988): entrenched
  SHIP (2000): artificial stream banks 2–3 m high
- **Bank** Composition:
  Norris (1988) comments: constructed stone walls
  SHIP (2000): the bed of the channel is formed on concrete
- Bank Stability:
  Noms (1988): 0% unstable
  SHIP (2000): no change from 1988
- Comments: Noms (1988) noted a fair amount of water seeping into channel

Location: Stn 10+62 to 12-1-88(District of Oak Bay)
Between Tennis Bubble culvert and Cadboro Bay Road culvert

- Water Quality Sample Sites: SHIP sites 5–6, CRD station no. 316-3
- Land Status:
  - Oak Bay Recreation Centre
  - commercial
- Recreation: parking lots on both sides of stream channel; not used as a walkway
- Road Crossings: culvert under Bee Street
- Crown Closure:
  Noms (1988): 60%
  SHIP (2000): no change since 1988
- Confinement:
  Noms (1988): entrenched

SHIP (2000):

- **Bank Composition:**
  Noms (1988) comments: mostly steep and natural
  SHIP (2000): cemented rock walls upstream of Bee Street; elsewhere stream banks have been modified and are composed of clay/till materials with extensive root systems from maples growing adjacent to the stream
- **Bank Stability:**
  Noms (1988): 0% unstable, but some surface erosion
  SHIP (2000): no change from 1988

Location: Stn 15+14 to 20+88 (District of Saanich)
Between Trent Street culvert and Richmond Road culvert

- **Water Quality Sample Sites:** SHIP sites **7–14**
- **Land Status:**
  - St. Patrick's Elementary School
  - Royal Jubilee Hospital
  - lot owned by the Bishop of Victoria is undeveloped
  - two lots owned by District of Saanich plus a portion of the Adanac Street right-of-way and Trent Street right-of-way are undeveloped
  - a large parcel owned by BC Hydro is undeveloped (used informally as a park)
  - multi-family residential
- **Recreation:** private vacant lands adjacent to the creek are used extensively by walkers and joggers
- **Road Crossings:** culvert under Haultain Street
- **Crown Closure:**
  Norris (1988): 5% (some trees recently removed), mostly upstream of Haultain Street
  SHIP (2000): 60-80% upstream of Haultain Street, 20–30% downstream of Haultain Street
- **Confinement:**
  Noms (1988): straightened and entrenched downstream of Haultain Street
  SHIP (2000): entire length is straightened and entrenched
- **Bank Composition:**
  Morris (1988) comments: heavily rooted with ground vegetation
  SHIP (2000): many clay/till banks were exposed
- **Bank Stability:**
  Norris (1988): **0%** unstable
  SHIP (2000): exposed banks, but little bank erosion; gravel/sand deposition area adjacent to St. Patrick's Elementary School suggesting some bank erosion in that area.
- **Comments:** fish are not present in this section, but Norris (1988) commented that the channel downstream of Haultain Street was relatively good fish habitat with lots of instream vegetation and some spawning gravel (which had a thick silt/organic covering)

Location: Stn **22+92** to **27+08** (District of Saanich)
Between Newton Street culvert and Pearl Street culvert

- **Water Quality Sample Sites:** SHIP site 13-1 5
- **Land Status:**
  - Richmond Elementary School
  - multi-family residential
- **Recreation:** walking or jogging is possible along the top of the ditch, but fences prevent access to the creek or continuous access along the creek
- **Road Crossings:** none
- **Crown Closure:**
  Norris **(1988): 30%**
  SHIP **(2000):** similar to **1988**
- **Confinement:**
  Norris **(1988):** channeled and entrenched
  SHIP **(2000):** stream banks **2–3** m high
- **Bank Composition:**
  SHIP **(2000):** banks composed of clay/till material; limited erosion evident
- **Bank Stability:**
  Norris **(1988): 10%** unstable
  SHIP **(2000):** likely same as in **1988**
- **Comments:** there is a chain-link fence around the entire section, crossed by two foot bridges

Location: Stn **40+08** to **46+50** (District of Saanich)
Between Shelley Street culvert and Knight Avenue culvert

- **Water Quality Sample Sites:** SHIP site **16–19**; CRD station no. 3 **16-4**
- **Land Status:**
  - single- and multi-family residential
  - Browning Park
  - one lot immediately upstream Keats Street owned by District of Saanich and portions of road rights-of-way on Shelley, Keats and Wordsworth streets are undeveloped
- **Recreation:** access along the stream for walking in Browning Park; only limited access at the footbridge crossing at Wordsworth Street
- **Road Crossings:** culvert under McRae Avenue
- **Crown Closure:**
  Norris **(1988): 80%**
  SHIP **(2000):** no change since **1988;** the area most exposed is the section at the Keats Street crossing that is completely without crown cover.
- **Confinement:**
  Norris **(1988):** entrenched
  SHIP **(2000):** mainly entrenched in gabions, lock blocks. and concrete walls downstream of Browning Park

- **Bank Composition:**
  Norris (1 **988)** comments: over hanging brush had been cleared recently
  SHIP **(2000):** no evidence of bank clearing
- **Bank Stability:**
  Norris **(1988):** steep banks, **10%** unstable in lower portion
  SHIP **(2000):** no change since **l988**

Location: Tributary 1 **–** upstream of Stn **101+62** (District of Saanich)
Upstream of Cedar Hill Road culvert

- **Water Quality Sample Sites: SHIP** site **20**
- **Land Status:**
  - Cedar Hill Recreation Centre
  - Cedar Hill Golf Course
- **Recreation:** usable area for walking and jogging
- **Road Crossings:** no road crossings, but several long culverts within the golf course
- **Crown Closure:** area is a wetland (crown close not applicable)
- **Confinement:** none
- **Bank Composition:** not evident
- **Bank Stability:** stable

Location: Tributary **2 –** upstream of Gordon Head Road culvert (District of **Oak** Bay)
Upstream of Gordon Head Road culvert

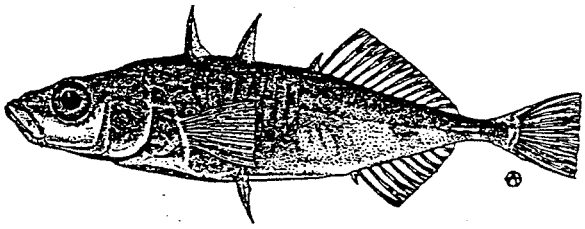
- **Water Quality Sample Sites:** SHIP site **2**1
- **Land Status:**
  - University of Victoria
- **Recreation:** useable area for walking and jogging
- **Road Crossings:** culvert under Faculty Club road
- **Crown Closure: 100%**
- **Confinement:** stream in wetland not confined
- **Bank Composition:** mainly organic material
- **Bank Stability:** no instability
- **Comments: A** storm drain system conveys drainage from most of the campus to an open channel on the west side of University Drive (''ring road''). Downstream of the Faculty Club road, the channel flows into a seasonal wetland that drains to a ditch alongside Gordon Head Road. The wetland is identified in the District of Saanich Environmentally Significant Areas Inventory **(1999).**

APPENDIX B

ILLUSTRATIONS OF AQUATIC SPECIES

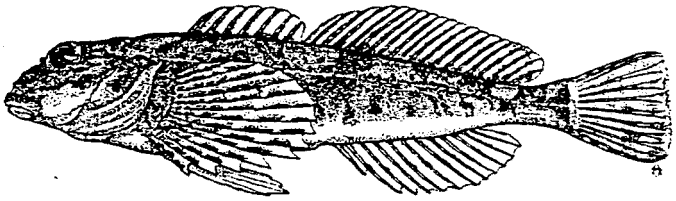
THREESPINE *STICKLEBACK*

Gasterosteus aculeatus Linnaeus



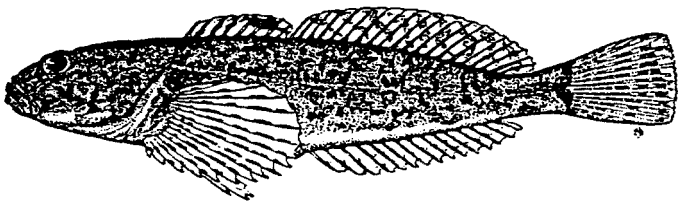
COASTRANGE SCULPIN

Cottus aleuticus Gilbert



PRICKLY SCULPIN

Cottus asper Richardson

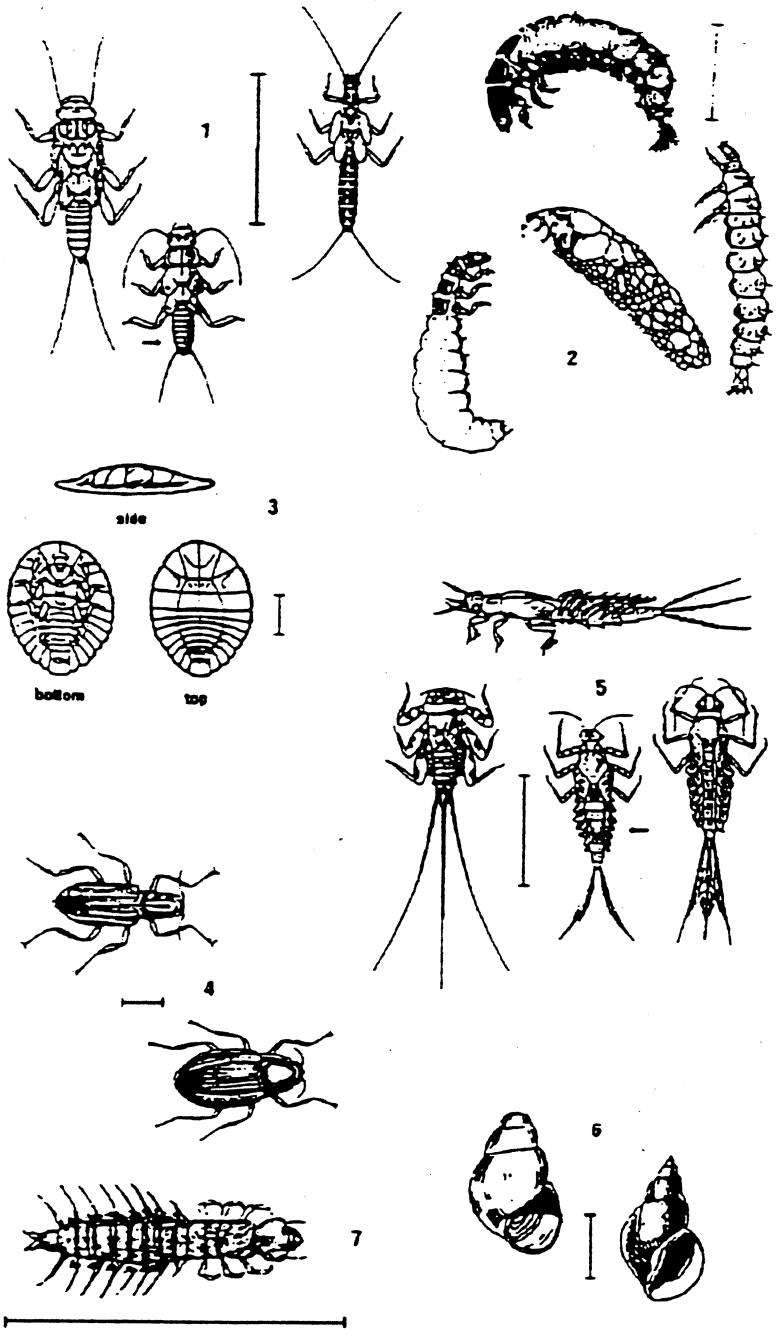


Fish species presently found in Bowker Creek

(from Scott **and** Crossman, 1973)

Appendix 1
Field Identification and Pollution Tolerance Chart

adapted from Save our Streams, Izaak Walton League of Amer



1 *Stonefly:*
Order Plecoptera
1/2" - 1 1/2", 6 legs with hooked ti antennae, 2 hair-like tails. Smoo (no gills) on lower half of body. (s arrow)

2 *Caddisfly:*
Order Trichoptera
up to 1", 6 hooked legs on upp third of body, 2 hooks at back en May be in a stick, rock or leaf ca with its head sticking out. May ha fluffy gill tufts on lower half.

3 *Water Penny:*
Order Coleoptera
1/4", flat saucer-shaped body with raised bump on one side and 6 ti legs on the other side. Immatu beetle.

4 *Riffle Beetle:*
Order Coleoptera
1/4", oval body covered with tiny hair 6 legs, antennae. Walks slow underwater. Does not swim c surface.

5 *Mayfly:*
Order Ephemeroptera
1/4 - 1", brown, moving, plate-like feathery gills on sides of lower bod (see arrow) 6 large hooked leg antennae, 2 or 3 long, hair-like tail Tails may be webbed together.

6 *Gilled Snail:*
Class Gastropoda
Shell opening covered by thin plat called operculum. Shell usually open on right.

7 *Dobsonfly (Helgrammite):*
Family Corydalidae
3/4 - 4", dark coloured, 6 legs, larg pinching jaws, 8 pairs feelers on lowe half of body with paired cotton-like g tufts along under-side, shor antennae, 2 tails and 2 pairs of hook at back end.

Category One Taxa

Pollution sensitive organisms found in good quality water

BAR INDICATES RELATIVE SIZE

Appendix 1
Field Identification and Pollution Tolerance Chart, *(continued)*

8 *Crayfish: Order Decapoda*
Up to 6", 2 large claws, 8 legs, resembles small lobster.

9 *Sowbug: Order Isopoda*
1/4 - 3/4", gray oblong body wider than it is high, more than 6 legs, long antennae.

10 *Scud: Order Amphipoda*
1/4", white to grey, body higher than it is wide, swims sideways, more than 6 legs, resembles small shrimp.

11 *Alderfly larva: Family Sialidae*
1" long, looks like small hellgrammite but has 1 long, thin, branched tail at back end (no hooks). No gill tufts underneath.

12 *Fishfly larva: Family Corydalidae*
Up to 1 1/2", looks like small hellgrammite but often a lighter reddish-tan colour, or with yellowish streaks. No gill tufts underneath.

13 *Damselfly: Suborder Zygoptera*
1/2 - 1", large eyes, 6 thin hooked legs, 3 broad oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (see arrow).

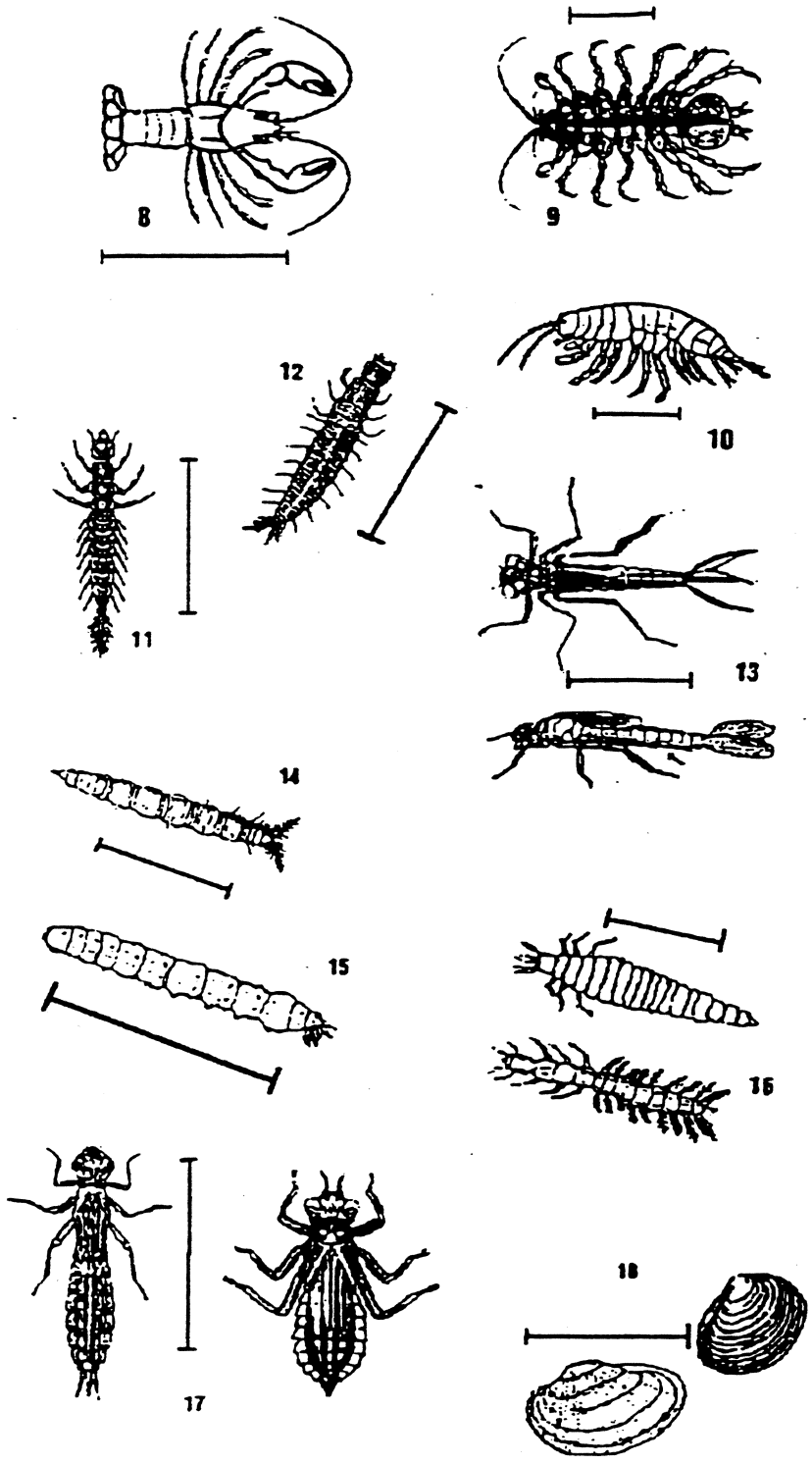
14 *Watersnipe Fly Larva: Family Athercidae (Atherix)*
1/4 - 1", pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

15 *Crane Fly: Suborder Nematocera*
1/3 - 2", milky, green, or light brown, plump caterpillar-like segmented body, 4 finger like lobes at back end.

16 *Beetle Larva: Order Coleoptera*
1/4 - 1", light-coloured, 6 legs on upper half of body, feelers, antennae.

17 *Dragon Fly: Suborder Anisoptera*
1/2 - 2", large eyes, 6 hooked legs. Wide oval to round abdomen.

18 *Clam: Class Bivalvia*

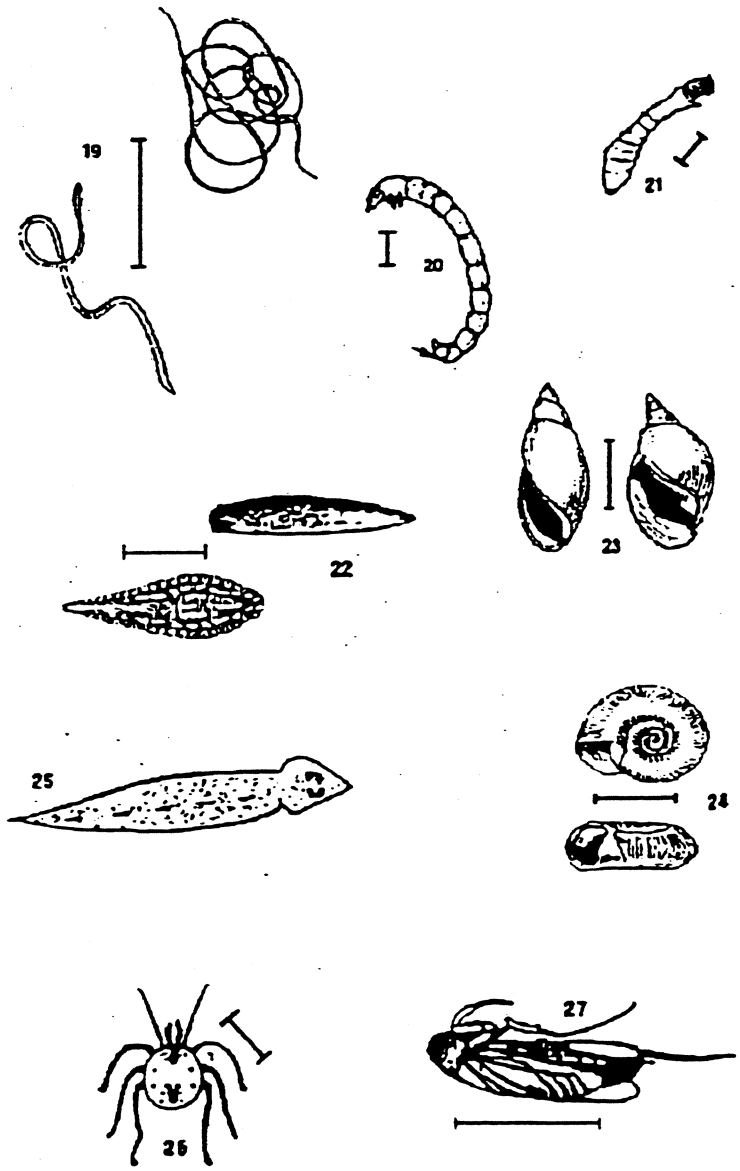


BAR INDICATES RELATIVE SIZE

Category Two Taxa

Somewhat pollution tolerant organisms can be in good or fair quality water.

Appendix 1:
Field Identification and Pollution Tolerance Chart, *(continued)*



19 *Aquatic Worm:*
Class Oligochaeta
1/4 - 2", can be very tiny, thin worm-lik body.

20 *Midge Fly Larva:*
Suborder Nematocera
Up to 1/4", dark head, worm-lik segmented body, 2 tiny legs on eac side.

21 *Blackfly Larva:*
Family Simulidae.
Up to 1/4", one end of body wider. Blac head, suction pad on end.

22 *Leech:*
Order Hirudinea
1/4 - 2", brown, slimy body, ends wit suction pads.

23 *Pouch Snail and Pond Snails:*
Class Gastropoda
No operculum. Breathe air. She usually opens on left.

24 *Other Snails:*
Class Gastropoda
No operculum. Breathe air. Snail she coils in one plane.

25 *Planarian:*
Class Turbellaria
Flattened, unsegmented worm-lik body, may have distint eyespots gliding movement.

26 *Water Mite: Order Hydracarina*
Looks like spider, may be very tiny, ha 8 legs.

27 *True Bug Adult:*
Order Hemiptera
Has short legs, swims or dives quickly

Category Three Taxa

Pollution tolerant organisms can be in any quality of water

BAR INDICATES RELATIVE SIZE