FRASER RIVER ACTION PLAN

Inventory of Golf Courses in the Fraser River Basin

DOE FRAP 1996-25

Environment Canada Environnement Canada

INVENTORY
OF
GOLF COURSES
IN THE
FRASER RIVER BASIN

FINAL REPORT

DOE FRAP 1996-25

Prepared for:

Fraser Pollution Abatement Office
Fraser River Action Plan
Environment Canada
North Vancouver, B.C.

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ABSTRACT

The golf industry has raised environmental concerns in recent years, likely due to its high profile and intense land management. The concerns are primarily related to surface and ground water quality and wildlife protection. This report on golf course practices was funded by Environment Canada under the Fraser River Action Plan through the Fraser Pollution Abatement Office to assess environmental aspects of golf courses in the Fraser River Basin.

The golf industry was studied over a seven month period in 1995. The study included a survey of current practices, a surface water and sediment sampling program, and interviews with government and golf association representatives. The study culminated in the development of this report, *Inventory of Golf Courses in the Fraser River Basin*, and an accompanying document on best management practices (BMP's) for golf courses, entitled *Greening your BC Golf Course. A Guide to Environmental Management*.

This report presents the results of a golf course inventory and five specific site assessments. It also summarizes conditions and practices in the Fraser Basin, reviews best management practices in other jurisdictions, and examines economic impacts of BMP implementation.

The inventory is based on the results of a survey developed and mailed to all golf course superintendents in the Fraser River Basin in 1995. The survey obtained information regarding the golf courses' location, layout, operation and management, and chemical controls for the past five years. In total, 44 of the 76 (58%) golf courses provided information.

Site assessments were conducted at 5 golf courses in the Fraser River Basin: three in the Lower Mainland, one in the South Thompson River Valley Region, and one in the Prince George Region. The site assessments specifically addressed the potential for surface water contamination as a direct result of golf course activities. Golf courses were examined with respect to topography, soils, turf, drainage, irrigation practices, maintenance area, housekeeping, chemical use and storage, and water quality monitoring. A limited water and sediment sampling program was conducted to characterize the quality of runoff from the courses.

The companion document, *Greening your BC Golf Course - A Guide to Environmental Management*, is intended to guide managers in the design and management of golf courses, and will benefit course owners, operators and golfers. The guide is available through Environment Canada, Fraser River Action Plan.

RÉSUMÉ

Le golf est un sport et un loisir de plus en plus populaire en Colombie Britanique. Chaque année, environ 450 000 golfeur(euse)s du Canada et d'autres pays fréquentent les 230 terrains de golf de la province. Le nombre de terrains de golf augmente d'environ 2 à 3 par année. Cette croissance suscite de plus en plus de préoccupations à caractère écologique, surtout reliées à l'eau de surface, l'eau souterraine, et à la protection de la faune et de la flore. Ce document sur les pratiques de gestion des terrains de **golf** dans le basin versant du fleuve Fraser a été financé par Environnement Canada, Plan d'Action du Fraser..

Le secteur du golf a été étudié pendant une période de sept mois en 1995. L'étude comportait un questionnaire sur les usages courants, un program d'échantillonnage des eaux de surface et des sédiments, et des entrevues avec des représentant(e)s d'associations de golf et du governement. Cette étude a permis la réalisation de ce document, ***Inventory of*** **Golf Courses** ***in the Fraser River Basin,*** et d'un document accompagnateur sur les meilleures pratiques environnementales, ***Greening your BC*** **Golf** ***Course. A Guide to Environmental Management.***

Ce document, ***Inventory of*** Golf ***Courses in the Fraser River Basin,*** présente les résultats d'un inventaire des terrains de golf et de cinq évaluations de site spécifiques. L'inventaire est basé sur les résultats d'un questionnaire développé et envoyé à tous les super-intendants en 1995. Les résultats du questionnaire donnent des informations sur la localisation, le design, la gestion des opérations, les contrôles chimiques au cours des cinq dernières années. Au total, 44 des 76 terrains de golf ont completé le questionnaire.

Les cinq évaluations de site avaient pour but d'évaluer le potentiel de contamination des eaux de surface résultant des activités sur le terrain de golf. Les variables suivantes ont été considérées: la topographie, les sols, la tourbe, le drainage, les pratiques d'irrigation, l'espace d'entretien, l'usage et l'espace de rangement des produits chimiques et la qualité de l'eau. Un programme d'échantillonnage d'eau et de sédiment a été développé pour caractériser la qualité des eaux de ruissellement provenant des terrains de golf

Le document accompagnateur ***Greening your BC Golf Course. A Guide to Environmental Management*** est un guide qui vise à amener les gestionnaires de terrains de golf à un design et une gestion quotidienne des terrains de golf qui puissent profiter à la fois aux propriétaires, aux super-intendants, aux golfeurs(euse)s, ainsi qu'au milieu naturel.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

Numerous organizations are working together to advance the environmental, economic and social sustainability of the Fraser River Basin. The Basin is a valuable resource -- while covering only 25% of B.C.'s land area, it contributes 80% towards the gross provincial product and over 60% towards total household income. The health of the Basin is however being strained due to population increases, resource extraction and rapid economic growth.

As part of the federal Fraser River Action Plan, the pressures facing the Basin's health and sustainability are being addressed. Pollution awareness and abatement are components of this Plan and as such, Best Management Practice plans or Pollution Prevention plans addressing surface water quality protection are being developed for a number of industry sectors.

The golf industry has become the focus of some environmental concerns in recent years, likely due to its high profile and intense land management. The concerns are primarily related to surface and ground water quality and wildlife protection. Many North American associations dedicated to the industry have begun to actively address these topics, as have university research programs. Local, regional and provincial/state governments have also begun to address these topics through the preparation of golf course development guidelines and, to a limited extent, operations guidelines. However, at the government level, the existence of comprehensive documents directed specifically to environmentally responsible golf course development and operation is a rarity.

The preparation of such documents presents a challenging task. Golf course development and operation is extremely site specific in nature: techniques will vary not only between biogeoclimatic regions, but also within a biogeoclimatic region and within a golf course. Factors affecting development and operation techniques include climate, soils and geology, turf selection, pest types (in the present context pests are those diseases, weeds, insects and animals that feed on, out-compete, destroy or reduce the quality of turfgrasses), the sophistication of the superintendent, the development and operating budget of the course and the demands of the ownership and the players. Guidelines on a national, or even provincial level, would out of necessity be quite general. While more specific guidelines can be developed on a municipal or regional level, the responsibility to develop an environmentally responsible management plan ultimately lies with the superintendent.

Undeniably, any efforts toward the environmentally responsible management of golf courses will help reduce potential environmental impacts. This report, *Inventory of Golf Courses in the Fraser River Basin*, and the companion report *Greening your BC Golf Course - A Guide to Environmental Management* were developed following a seven month study of the golf course industry to provide guidance to golf course superintendents, their workers, golf course managers, owners and players.

This report contains results from a survey of the golf courses in the Fraser River Basin, five golf course site assessments which included a limited surface water and sediment sampling program, a literature review, and interviews with government and golf association representatives. Finally, a cursory analysis of the economic impacts of BMP implementation was performed.

2.0 GOLF COURSE INVENTORY

The intent of the golf course inventory was to obtain information regarding the location, layout, operation and management of golf courses within the Fraser River Basin. Particular attention was given to the use of chemical controls within the past five years (1990-1994). In general, the inventory process consisted of: i) identifying the courses within the Basin boundaries; ii) a mail out of surveys to all course superintendents; iii) follow up calls to superintendents not responding to the survey; and iv) resending (by fax) surveys to superintendents agreeing to participate in the survey. In total, responses from 41 of the 76 courses in the Basin were obtained, approximately 58%.

2.1 INVENTORY PROCESS

The publication *Water in Sustainable Development: Exploring Our Common Future in the Fraser River Basin* provided a listing of the incorporated communities within the study area (Table 2.1). In turn, the golf courses within each of these communities were identified through reference to the *1995 British Columbia Tee Off Golf Guide,* which lists all B.C. Golf Association member courses, whether private, semi-private or public. National Topographic Service (NTS) 1:50 000 scale maps were used to confirm the location of these courses within the drainage Basin boundaries. Contact names at the golf courses were obtained from the 1994 B.C. Golf Course Superintendents Association (BCGCSA) membership list and the *Tee Off Golf Guide*.

The content and layout of the survey was reviewed by Environment Canada, the GVRD and Mr. Brad Stuart, Past-President of the BCGCSA. From discussions with Mr. Stuart and a few additional superintendents, it was decided that it would be unnecessary to offer anonymity to the respondents of the survey -- it was felt that, in general, superintendents would be anxious to demonstrate their environmental responsibility. While it was considered advantageous to obtain the BCGCSA's endorsement to encourage response, it could not be obtained by the time of the mail out and was therefore not pursued further. A copy of the survey has been included in Appendix A.

The mail out of the surveys took place in April 1995. Due to the poor initial response, follow up calls were made in August and October, closer to the end of the golfing season, when superintendents were expected to have more available time. With the superintendents contacted, every effort was made to complete as much of the survey over the telephone as possible. Typically, however, pesticide and fertilizer data was not readily available. Therefore, this portion of the survey was resent (faxed) to those superintendents agreeing to complete and return the form within the following two weeks. In most cases, the extent of the data requested was reduced to encourage cooperation (ie. 2 year's worth of past data was requested, rather than 5).

To augment the information collected from the mail out and the interviews, a number of other sources were referenced. In general, it was necessary to obtain pesticide specific information such as registration numbers (PCP numbers), recommended application rates and fractions of active ingredient from chemical suppliers, B.C. Environment's Pesticide Control Branch or Agriculture Canada. Toxicity information was obtained from published literature. Municipalities and chemical suppliers were contacted to confirm the pesticide and fertilizer use data of a number of municipally managed golf courses. NTS 1:50 000 scale maps were consulted to confirm the latitudes and longitudes of the golf courses and their proximity to watercourses.

TABLE 2.1
Incorporated Communities within the Fraser River Basin.

Regional District/ Municipality	Fraser Basin Region
Buckley-Nechako	
Burns Lake	Upper Fraser
Fort St. James	Upper Fraser
Fraser Lake	Upper Fraser
Vanderhoof	Upper Fraser
Cariboo	
Quesnel	Middle Fraser
Williams Lake	Middle Fraser
100 Mile House	Thompson
Central Fraser Valley	
Abbotsford	Lower Fraser
Langley (City/District)	Lower Fraser
Matsqui	Lower Fraser
Columbia-Shushwap	
Salmon Arm	Thompson
Dewdney-Alouette	
Maple Ridge	Lower Fraser
Mission	Lower Fraser
Pitt Meadows	Lower Fraser
Fraser Cheam	
Chilliwack	Lower Fraser
Hope	Lower Fraser
Kent	Lower Fraser
Harrison Hot Springs	Lower Fraser
Fraser-Fort George	
McBride	Upper Fraser
Prince George	Middle Fraser
Valemount	Upper Fraser
Greater Vancouver	
Burnaby	Lower Fraser
Coquitlam	Lower Fraser
Delta	Lower Fraser
Langley (Twnshp/District)	Lower Fraser
New Westminster	Lower Fraser
Port Coquitlam	Lower Fraser
Port Moody	Lower Fraser
Richmond	Lower Fraser
Surrey	Lower Fraser
Vancouver	Lower Fraser
North Okanagan	
Enderby	Thompson
Lumby	Thompson
Spallumcheen	Thompson
Squamish-Lillooet	
Lillooet	Middle Fraser
Pemberton	Lower Fraser
Whistler	Lower Fraser
Thompson-Nicola	
Ashcroft	Thompson
Cache Creek	Thompson
Chase	Thompson
Clinton	Thompson
Kamloops	Thompson
Logan Lake	Middle
Lytton	Thompson
Merritt	Thompson

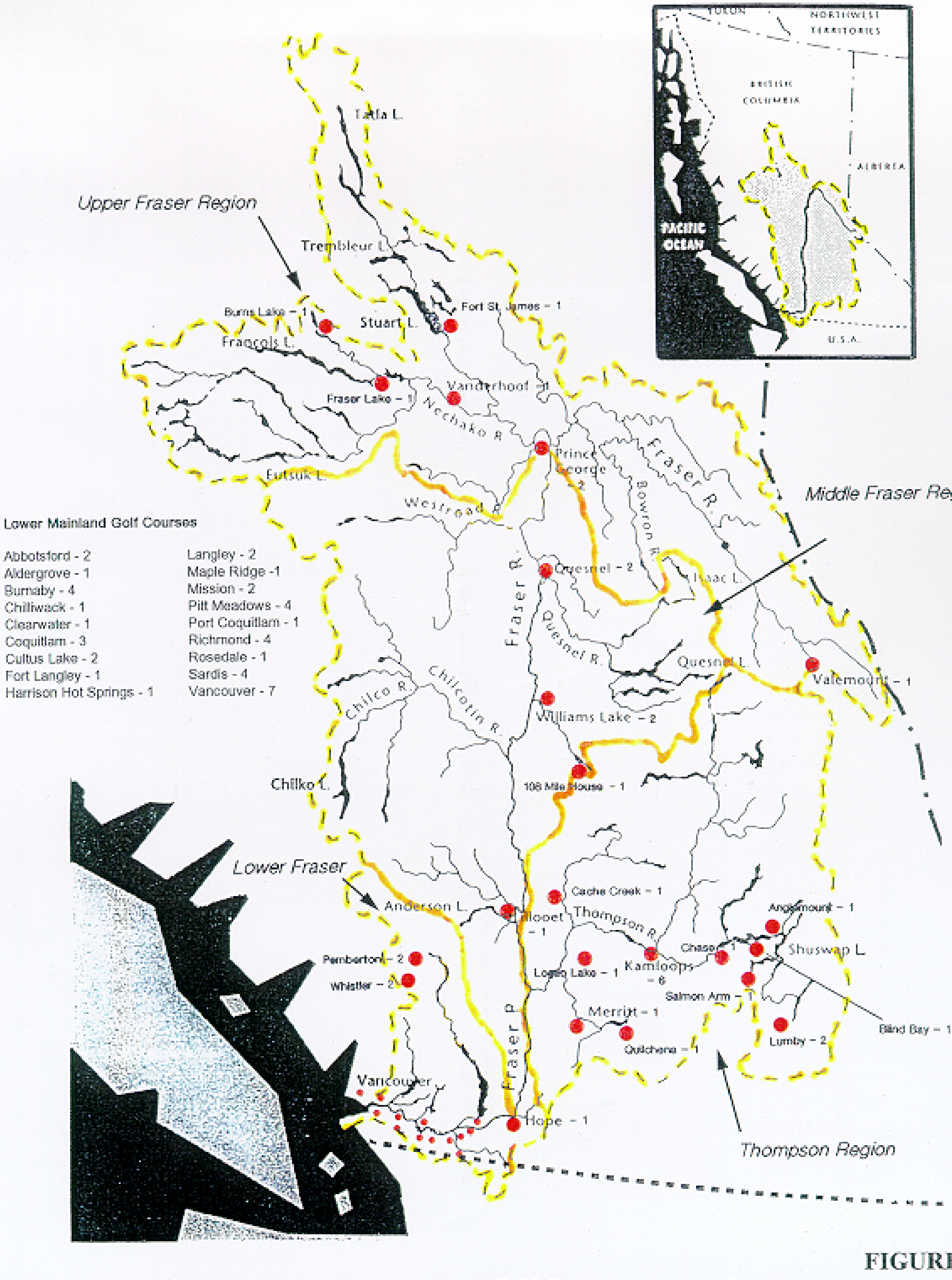

FIGURE 2.1
Golf Course Locations in the Fraser River Basin

2.2 INVENTORY RESULTS

There are 76 golf courses located within the boundaries of the Fraser River Basin, including those currently closed for renovation or currently under construction and scheduled to open within 1995. The majority, 41, are located in the Lower Mainland; 28 are located in the Greater Vancouver Regional District. Figure 2.1 depicts the distribution of golf courses within the Basin.

It was recognized that the response to the April mail out could be poor due to: i) the demands on the superintendents during the peak golfing season; ii) the time that would be required to obtain the necessary data and complete the survey; and iii) the lack of incentive to participate in the study. In fact, from the initial mail out less than 10 completed surveys were returned. Through follow up calls only another 35 superintendents could be contacted, although messages were left at virtually all of the courses. Approximately 30 of these superintendents agreed to complete a portion of the survey over the telephone and complete the remainder (the pesticide and fertilizer use portion) within 2 weeks. Less than 10 superintendents completed and returned this final portion of the survey.

Overall, data from 44 of the 76 courses (58%) was obtained. The responses came from each of the four Fraser River Basin regions: the Thompson Region and the Lower, Middle and Upper Fraser Regions. Generally, the data obtained from the mail out and the interviews was incomplete or contained discrepancies. Additional telephone calls to a number of agencies (as described in Section 2.1) were necessary to provide a more complete profile of the golf courses in the Basin. The information collected has been presented in five tables, Tables 2.2 - 2.6.

Table 2.2 summarizes general information regarding the golf courses in the Basin: information regarding contacts at the courses (ie. general manager and superintendent) and information regarding course location (ie. municipal address, latitude/longitude, closest watercourse).

Table 2.3 summarizes information regarding each facility (ie. type of course, age, layout, chemical storage) and its operation and management practices (ie. irrigation, equipment washing, water quality monitoring, pest problems).

Tables 2.4 & 2.5 detail chemical use at the courses over the past five years. Fertilizer information including composition, recommended application rate, application location and the amounts of nitrogen, phosphorous and potassium applied can be found in Table 2.4; information regarding the location and amount of pesticides applied and the target species can be found in Table 2.5. General pesticide data such as fraction active ingredient, recommended application rate, target biota and toxicity are summarized in Table 2.6.

TABLE 2.2
Fraser River Basin Golf Courses

Course	Municipality	Address	Phone/Fax[1]	General Manager	Superintendent	Location		Closest Watercourse	
						latitude	*longitude*	*name*	*distance (km)*
108 Resort Golf Course	108 Mile Ranch	P.O. Box 2, V0K 2Z0	791-5211 / - / 791-6537	John Williams	Eric Wastrom	51° 44.0'	121° 20.5'	108 Mile L.	adjacent
Aberdeen Hills Golf Links	Kamloops	1185 Links Way, V1S 1S8	828-1143 / - / -	Art Cordero	Biron Duffey	50° 38.5'	120° 21.5'	tributary to Guerin Ck.	< 0.5
Anglemount Estates Golf Club	Anglemount	P.O. Box 48, V0E 1A0	955-2211 / - / -	Ken & Kathie Miller	Ken Miller	50° 58.1'	119° 0.5'	Shuswap L.	< 1
Aquadel Golf Course	Cultus Lake	1859 Columbia Valley Highway, V0X 1P0	858-6896 / - / 858-6285	Dick Whitlam	Dick Whitlam	49° 2.0'	122° 0.5'	Spring Ck.	through course
Aspen Grove Golf Course	Prince George	Highway #97 South, V2N 4M6	963-9650 / - / 963-8801	Vernon Norbraten	Vernon/Gary Norbraten	53° 50.0'	122° 41.0'	Taber Ck.	< 2
Bell-E-Acres Par 3 Golf Course	Williams Lake	1313 Hodgson Road, V2G 2P1	398-6313 / - / -			122° 11.5'	52° 6.5'	Williams Lake R.	~ 3
Belmont Golf Course	Langley	22555 Telegraph Trail, V3A 8G6	888-2393 / 888-9389 / 888-9696		Joe Veller	49° 9.5'	122° 35.5'	Salmon R.	adjacent
Big Sky Golf & Country Club	Pemberton	Airport Road, P.O. Box 688, V0N 2L0	894-6106 / - / 894-5545	Ed McLaughlin	Jim O'Connor	50° 18'	122° 46'	Green R./Lillooet R.	adjacent
Bridal Falls Golf & Country Club	Rosedale	53191 Bridal Falls Road, V0X 1X0	794-7788 / - / -	Norm Gaukel	Norm Gaukel	49° 10.5'	121° 45.25'	Bridal Ck.	< 1
Burnaby Mountain Golf Course	Burnaby	7600 Halifax Street, P.O. Box 82067, V5C 4M8	421-8355 / 970-6438 / 294-7535	Richard Leisen	Garry Hogan	49° 16.0'	122° 56.5'	tributary to Burnaby L.	through course
Carnoustie Golf & Country Club	Burns Lake	Highway 16, RR#1, V0J 1E0	698-7677 / - / -	Moira Lindaas	Stanley Lindaas	~ 54° 20.5'	~ 125° 53'	Decker L.	~ < 1
Carnoustie Golf Club	Port Coquitlam	533 Dominion Avenue, V3C 3V4	941-4076 / - / -	Ingrid Hart	Dale	49° 15.5'	122° 44'	tributary to Pitt R.	through course
Central Park Pitch & Putt Golf Course	Burnaby	3883 Imperial Street, P.O. Box 82067, V5C 5P2	434-2727 / 970-6437 /-	Richard Leisen	Rod Sideroff	49° 13.5'	123° 1.0'	Fraser R., North Arm	< 2.5
Chateau Whistler Golf Club	Whistler	4612 Blackcomb Way, V0N 1B4	938-2092 / 938-4912 / 938-0368	Dave Gordon	A.J. Pratt	50° 7.25'	123° 56.5'	Horstman Ck./Blackcomb Ck.	through course
Cheam Golf Course	Sardis	44160 Luckakuck Way, V2P 6J7	858-7991 / - / -		Reid Grosart	49° 8.5'	121° 58.5'	Atchelitz Ck.	~ 1
Chilliwack Golf & Country Club	Sardis	41894 Yale Road, V2R 1A5	823-4544 / - / 823-4430	Brenda van der Veen	Duan Grosart	49° 7.75'	122° 4.0'	McGillivary Ck.	adjacent
Cultus Golf Park Resort	Cultus Lake	"Fore" Thousand Columbia Valley Hwy, V0X 1H0	858-9902 / - / 858-2612	Rob Bahnman	Rob Bahnman	49° 4.5'	121° 58.0'	Cultus L.	1
Dragon Lake Golf Course	Quesnel	1692 Flint Street, Box 13, V2J 4M1	747-1358 / - / -			52° 57'	122° 26.5'	Dragon L.	adjacent
Eagle Point Golf & Country Club	Kamloops	8888 Barnhartvale Road, V2C 2V3	573-5547 / 573-3284 / 573-4810		Neil Harasemchuk	50° 38.0'	120° 8.0'	Juniper Cr./Campbell Cr.	< 0.5
Eighteen Pastures Golf Course	Mission	29110 Matheson Avenue, V2V 6Y5	462-8622 / - / -	Wayne Lindberg	Wayne Lindberg	49° 11.5'	122° 22.5'	Hayward L.	< 1
Fort Langley Golf Course	Fort Langley	9782 McKinnon Crescent,V1M 2R5	888-5911 / - / 888-5922	Loc Huynh	Michael O'Brien	49° 10.25'	122° 35.5'	Salmon R. and Fraser R.	adjacent
Fraserglen Golf Course	Abbotsford	36036 S. Parallel Road, V3G 2K4	852-3477 / 852-6718 / -	Peter Driedger	Mike Weatherby	49° 1.0'	122° 14.0'	Lonzo Ck.	adjacent
Fraserview Golf Course	Vancouver	7800 Vivian Street, V5S 2V8	327-5616 / - / -		Howard Normann	49° 12.5'	123° 2.75'	Fraser R., North Arm	< 0.5
Golden Eagle Golf & Country Club	Pitt Meadows	Ladner Road (off Neaves Road), V3Y 1Z1	465-2656 / - / -	Jim Moylan	Tim Kubash	49° 16.0'	123° 8.5'	North Alouette R.	< 2
Greenacres Golf Course	Richmond	5040 No. 6 Road, V6V 1T1	273-1091 / - / -		Richard Krahn	49° 11.5'	123° 3.5'	Fraser R./Fraser R., North Arm	~ 3
Hope Golf & Country Club	Hope	Golf Course Road, Box 197, V0X 1L0	869-5881 / 869-2582 / -	Joan Nichols	Rod MacDonnell	49° 23.5	121° 26'	Fraser R./Coquihalla R.	adjacent
Kamloops Golf & Country Club	Kamloops	#16 - 2960 Tranquille Road, V2B 8B6	376-8020 / 554-1441 / -		Biron Duffey	50° 42.25'	120° 25.0'	Thompson R.	adjacent
Kensington Park Pitch & Putt Golf Course	Burnaby	5889 Curtis Street, P.O. Box 82067, V5C 5P2	291-9525 / 970-6438 / 294-7535	Richard Leisen	Garry Hogan	49° 16.75'	122° 58.5'	tributary to Still Ck.	< 1
Kinkora Golf Course	Sardis	46050 Higginson Road, V2R 2A9	858-8717 / - / 858-8494	Don Forbes	Todd McKay	49° 7.25'	121° 55.5'	Chilliwack Ck.	< 0.5
Lacarya Golf Course	Clearwater	3616 Old N Thompson Hwy, V0E 1N0	587-6100 / - / 587-6100	Stan Saari	Stan Saari	51° 33.5'	120° 8.5'	North Thompson R.	< 0.5
Langara Golf Course	Vancouver	6706 Alberta Street, V5Y 3N5	327-4423 / 257-8350 / 257-8636		Bob Giesbrecht	49° 13.25'	123° 6.5'	Fraser R., North Arm	1.5
Ledgeview Golf & Country Club	Abbotsford	35977 McKee Road, Box 152, V2S 4W7	859-8993 / 852-3386 / -		Chad Burns	49° 52.5'	122° 1 5.0'	trib. to Poignant/Clayburn Ck.	adjacent
Lumby Golf Course	Lumby	Highway #6 East, V0E 2G0	547-6339 / - / -			50° 15.0'	118° 57.25'	Bessette Ck.	< 0.5
Maple Ridge Golf Course	Maple Ridge	20818 Golf Lane, V2X 1M2	465-9221 / - / -		Don Levack	49° 12.75'	122° 38.5'	tributary to Pitt R.	through course
Marine Drive Golf Club	Vancouver	7425 Yew Street, V6P 6H1	261-8111 / 261-4815 / 261-8125		Wade Hawksworth	49° 13.0'	123° 10.0'	Fraser R., North Arm	adjacent
Mayfair Lakes Golf & Country Club	Richmond	5460 No. 7 Road, V6V 1R7	273-0585 / 273-6521 / -	Allen May	Steve May	49° 11.5'	123° 2.5'	Fraser R., North Arm	~ 2
McArthur Island Golf Course	Kamloops	Island Parkway N, Box 2097, Stn A, V2B 7K6	523-6666 / 554-3211 / -	Bill Bilton	Clarence Nelson	50° 41.75'	120° 22.75'	Thompson R.	adjacent
McCleery Public Golf Course	Vancouver	7170 MacDonald Street, V6N 1G1	261-4524 / - / -		Stan Dixon	49° 13.0'	123° 10.25'	Fraser R., North Arm	adjacent
Meadow Creek Golf Club	Logan Lake	Meadow Creek Road, P.O. Box 827, V0K 1W0	885-9212 / - / -	Gail Cooper		50° 29.75'	120° 47.25'	tributary to Logan Lake	< 0.5
Meadow Gardens	Pitt Meadows	19675 Meadow Gardens Way, V3Y 1Z2	465-5474 / 465-9828 / 465-8470	Sharon Kyle	Cameron Hart	49° 15.5'	122° 41.5'	Cranberry Slough	adjacent
Meadowlands Golf & Country Club	Chilliwack	47823 Yale Road E, V2P 7N3	792-2276 / 792-4900 / -	Robin Mulholland	Cliff Hill	49° 11.5'	121° 53.5'	Hope R.	adjacent
Melsview Links Golf Club	Valemount	P.O. Box 113, V0E 2Z0	566-4462 / - / -			52° 49.25'	119° 16.75'	tributary to McLennan R.	adjacent
Merritt Golf & Country Club	Merritt	Site 46, Comp 10, RR#1, V0K 2B0	378-9414 / - / -		Jeff Wiley	50° 7.0'	120° 48.5'	tributary to Nicola R.	adjacent
Mission Golf & Country Club	Mission	7983 Nelson Street, V2V 4J4	826-7617 / - / 826-7603	George Thibodeau	Mark Van Pelt	49° 57.75'	122° 21.5'	Chester Ck./Silverdale Ck.	< 0.5
Molyhills Golf Course	Fraser Lake	P.O. Box 268, V0J 1S0	699-7761 / - / -			~ 54° 0'	~125° 0'	Francois L.	adjacent
Mount Paul Golf Course	Kamloops	615 Mt Paul Way, V2H 1A9	374-4653 / - / -		Jay Barlow	50° 41.0'	120° 19.5'	South Thompson	< 1

Course	Municipality	Address	Phone/Fax [1]	General Manager	Superintendent	Location		Closest Watercourse	
						latitude	*longitude*	*name*	*distance (km)*
Musqueam Golf Club & Training Centre	Vancouver	3904 W 51 Avenue, V6N 3W1	266-2334 / 266-2873 / 266-8288	Andy Girling	Greg Wadden	49° 13.25'	123° 11.0'	Tin Can Ck./Fraser R.	through course / adj.
Mylora Golf Course	Richmond	9911 Sidaway Road, V6W 1C1	271-5626 / - / 271-5650		Dave Harrison	49° 8.75'	123° 4.5'	Fraser R.	~ 1.2
Nicola Valley Golf Course & R.V. Park	Quilchena	Highway #5A, V0E 2R0	378-2923 / - / -	Rosella Nielson		50° 9.5'	120° 30.5'	Quilchena Ck.	through course
Oak Tree Golf Course	Harrison Hot Springs	c/o Harrison Hot Springs Hotel, V0M 1K0	796-9009 / - / -	J. Hadway	Max Bannerman	49° 14.0'	121° 44.5'	Harrison Lake	< 5
Omineca Golf & Country Club	Vanderhoof	Northside Road, P.O. Box 1754, V0J 3A0	567-2920 / - / -	Norm Avison		54° 27.5'	124° 0.25'	tributary to Nechako R./Nechako R.	through course / 2
Pemberton Valley Golf & Country Club	Pemberton	Airport Road, V0N 2L0	894-5122 / - / -	Bruce Jaffary		50° 18.0'	122° 45.3'	Lillooet R./Green R.	adjacent
Pineridge Golf Course	Kamloops	4725 E Trans Canada Hwy, V2C 4S4	573-4333 / - / -	Cindy Piva	Darrell Dixon	50° 40.0'	120° 77.5'	South Thompson R.	adjacent
Pitt Meadows Golf Club	Pitt Meadows	13615 Harris Road, P.O. Box 29, V3Y 2E5	465-5431 / 465-5493 / 465-1611		Doug Kvas/Vern Johnson	49° 14.5'	122° 41.5'	Cranberry Slough	through course
Point Grey Golf & Country Club	Vancouver	3350 S.W. Marine Dr., V6N 3Y9	266-7171 / 263-5444 / -	-	Colin Softly	49° 13.25'	123° 10.5'	Fraser R.	adjacent
Poppy Estates Golf Course	Aldergrove	3834 - 248 Street, V4W 1Z2	856-1181 / - / -		Ken O'Reily	49° 4.25'	122° 32.0'	Murray Ck.	< 0.5
Prince George Golf & Curling Club	Prince George	Junction of Hwy. 97 & 16, Box 242, V2L 4S1	563-0357 / - / 563-4136	Niel King	Stephen Kerbrat	53° 53.5'	122° 46.5'	Fraser R.	< 3.5
Quesnel Golf Course	Quesnel	North Fraser Drive, V2J 4M1	249-5550 / - / 249-5296	Noel Pumfrey	Noel Pumfrey	53° 1.0'	122° 33.3'	tributary to Bouchie Ck./Fraser R.	through course / < 2
Redwoods Golf Club (The)	Langley	22011 - 88 Avenue, V1M 2M3	882-5130 / 882-9710 / 882-9710	Larry Hope	Doug Esperanza	49° 10.25'	122° 37.0'	Salmon R.	< 2
Richmond Country Club	Richmond	9100 Steveston Hwy, V7A 1M5	277-3141 / - / 241-3737		Martin Wilcox	49° 8.0'	123° 7.25'	Fraser R.	~ 1.5
River Ridge Golf Course	Lumby	Box 1071, V0E 2G0	547-9660 / - / -	Alfred Tonn	Alfred Tonn	50° 15.25'	118° 46.0'	Shuswap R.	through course
Rivershore Golf Club	Kamloops	Old Shuswap Rd, Comp 1, Site 13, RR#2, V2C 2J3	573-4211 / - / -		Terry Smith	50° 40.0'	~ 120° 2.0'	South Thompson R.	adjacent
Riverway Public Golf Course	Burnaby	9001 Riverway Place, V5J 5J3	433-3205 / 970-6437 / 294-7535		Rod Sideroff	49° 12.5'	122° 59.5'	Nelson, Sussex & trib. to Burn Ck.	through course
Royalwood Golf Club	Sardis	41050 Trans Canada Hwy, V2R 1A9	823-4653 / - / 823-4665		Dan Ehrenholz	49° 7.5'	122° 5.0'	Vedder Canal	adjacent
Salmon Arm Golf Course	Salmon Arm	Hwy 97B S, P.O. Box 1525, V1E 4P6	832-4727 / 832-8834 / 832-6311	Clif Bennett	Kevin Potter	50° 40.5'	119° 13.0'	Canoe Ck.	through course
Semlin Valley Golf Club	Cache Creek	Box 421, V0K 1H0	457-6666 / - / -			50° 48.5'	121° 18.75'	Cache Ck.	< 0.5
Shaughnessy Golf and Country Club	Vancouver	4300 SW Marine Drive, V6N 4A6	266-4141 / - / -		Brian Houston	49° 14.5'	123° 12.25'	Fraser R., North Arm	adjacent
Sheep Pasture Golf Course	Lillooet	Texas Creek Road, Box 217, V0K 1V0	256-4484 or 256-7032/ - / -	David Jones	David Jones	~ 50° 38.25'	~ 121° 53.5'	Fraser R.	< 2
Shuswap Lake Estates Golf & Country Club	Blind Bay	Box 150, V0E 1H0	675-2315 / 675-2523 / 675-2526		Don Parker	~ 50° 52.25'	~ 119° 3.0'	Shuswap L.	< 3
Stuart Lake Golf Club	Fort St. James	Box 158, V0J 1P0	996-8736 / - / -			54° 27.25'	124° 16.5'	Stuart L.	< 0.5
Sunshore Golf Course	Chase	Hysop Street, Box 260, V0E 1M0	679-3021 / - / 679-3072	Judy Johnson	Larry Barton	50° 48.0'	119° 41.0'	Little Shuswap L.	adjacent
Swan-e-set Bay Resort & Country Club	Pitt Meadows	16651 Rennie Road, V3Y 1Z1	465-9380 / 465-6328 / 465-3727	Jeff Teich	Brad Kutyn	49° 17.0'	122° 38.5'	Sturgeon Slough/Pitt R.	adjacent
Vancouver Golf Club (The)	Coquitlam	771 Austin Avenue, V3J 7A2	936-3404 / - / -		Stan Kazymerchyk	49° 15.5'	122° 52.5'	Brunette R.	storm sewer to ck. - 1.5
Westwood Plateau Golf & Country Club	Coquitlam	Plateau Boulevard, V3E 2Y5	944-0227 / 945-0804 / 945-6467	Jim McLaughlin	Bruce Thrasher	49° 18.5'	122° 47.0'	Hoy Ck./ Scott Ck.	through course
Westwood Plateau Golf Academy	Coquitlam	1630 Parkway Boulevard, V3E 2Y5	941-4236 / 945-0804 / 945-6467	Jim McLaughlin	Bruce Thrasher	49° 18.75'	122° 47.0'	Scott Ck./Noons Ck.	through course
Whistler Golf Club	Whistler	4010 Whistler Way, V0N 1B4	932-3280 / 932-3835 / -		Dave Gottselig	50° 6.75'	122° 57.75'	Alta L.	< 1
Williams Lake Golf & Tennis Club	Williams Lake	104 Fairview Drive, V2G 3T1	392-6026 / 392-3423 / 392-6005		Ken Krueger	52° 7.25'	122° 8.75'	Williams Lake R.	< 0.5

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[1] If available, i) main clubhouse telephone number, ii) maintainance telephone number & iii) general fax number were listed.

TABLE 2.3

Facility/Operation Data for Fraser River Basin Golf Courses

Course	Course Type	Age of Course (yrs)	Area - total	Area - fairways	Area - greens	Area - tees	Area - water (hectares)	Area - manicured rough	Area - unmanicured rough	Area - parking lot	Area - clubhouse	Area - other	Documented Management Plan	Annual Irrigation (m³)	Irrigation Source	Water Rights Permit	Licenced Volume (m³/y)	Water Quality Monitoring	Requesting Agency	Underdrain Collection System	Equipment Wash Water Drainage	Wash Chemicals Used	Certified Pest Control Manager	Common Pests	Chemical Storage	Comments
108 Mile House	18/P	26	82.22										N	< 100 600	108 Mile L.	Y	~201 000	Y	O	N	g	N	Y	sm, d	I, v, no fd	- monitor pH of lake water; compost grass clippings; soil samples analyzed every 2 years for guidance in developing fertilizer plan
Aquadel	18/P	30	10.13		0.5063	0.2025	-	-	-	0.2025			N	~25 000	well	N	-	Y	M	N	g	N	Y	F, sm, d, cw	I, no fd	- public health dept. monitors well; UBC study of on-site fisheries habitat; pesticides purchased as required; use herbicides once every 2 yr
Aspen Grove	18/P	15	41.72	22.275	1.215	1.215	3.24	4.05	4.86	0.81		4.05	N		creek through course and well	Y		N	-	Y	g	N	Y	th, cl, d, sm	I, v, no fd	- often use compressed air for cleaning equip. - clippings disposed of in dumpster; Scotts advises on chemical use
Belmont	18/SP	2	48.00	14.16	1.21	1.21	3.92	18.21		9.29			F, P		Salmon R.	Y	see comment	Y	M	Y	st	N	Y	psm	v, sf	- course has a Water Rights Permit for use of springs, however, water in ponds is sufficient for irrigation
Big Sky	18/SP	1											N		groundwater recharge of ponds	N	-	N	-	Y	g	N	Y	sm, cl, blw, nlp	I, v, scm (ChemLock)	
Bridal Falls	9/SP	1																								
Carnoustie (Burns L.)	9/P	18	20.25										N		snow melt collected in ponds	N	-	N	-	N	g	N	N	d, th	I (shed)	- primary method of control for Cdn. thistle & dandelion is cutting; do not fertilize fairways every year; only irrigate greens; Scotts advises on chemical use
Central Park	18/P	> 30			0.511								N	no meter	city water	N	-	N	-	Y	st	N	Y	ds, F, bp, algae, anthr.	none	- chemicals stored at Riverway & transported as needed to Central Park; wash water from chemical transport tanks goes to sewer
Chateau Whistler	18/P	3	38.48	18.225	1.0125	1.0125	2.43	16.2		0.81		-	N	22 700	Horseman Ck.	Y		Y	O	Y	sump	N	Y	sm, ta, cl	I, v, sf	- wash water to oil/water separator - grass clippings removed each week - water discharged to ground; water monitoring results submitted to municipality
Chilliwack	18/SP	37	48.60	14.175	0.93	0.93	-	18.225		~ 0.81		2.025	N	2.7/min.	drainage ditch through course	N	-	Y	O	N	g	N	Y	F, psm, blw, cl	I, no fd	- top dress fairways with sand to improve drainage
Cultus	18/P		22.28	12.15	0.81	0.6075	1.215	1.8225	2.025	0.81	0.81	2.025	N	550/d	well	N	-	N	-	N	g	N	Y	sm		
Dragon Lake	9/SP	15																								
Eagle Point	18/P	4	66.02	35.64	1.215	1.215	0.81	16.2		1.215		1.215	N	1800/d - dry cond.	Thompson R.	Y		Y	O	N	tank	N	Y	sm, Py, ls, ds, d	no storage	- order chemicals as required; wash water to holding tank for discharge to course - clippings mixed with soil for new construction
Eighteen Pastures	18/P		54.68	34.425	4.05	2.025	0.81	0.81	12.15				N		Hayward L.	Y		N	-	N	g	N	N	d	none	- do not store chemicals on-site; use manual methods for control of dandelions
Fort Langley	18/SP	25	43.71	20.23	2.02	2.02	0.80	8.10	7.29	0.65	0.04	2.58	N	6 200	Salmon R.	Y	6165	Y	O	Y (limited)	g	N	N	F, ta	I (room in barn)	- Scotts advises on chemical use
Fraserglen	18/P	>30																								
Fraserview	18/P	~ 60																								
Golden Eagle	36/SP	<1	~89	20.25	2.79	2.23	16.20	40.50		4.05		-	N	~135 500	runoff & Pitt R. tributary			N	-	Y	irrig. pond	N	Y	cat., ds, ta	to be built	- manual methods used for catepillar control; NH4SO4 used for take-all patch
Greenacres	18/P	30																								
Hope	9/SP	31	40.5	6.075	0.6075	0.405	0.20	12.15		1.215		1.62	N	~ 2 300	pond recharged by Coquihalla R.	N	-	N	-	N	g	N/Y	Y	d, cl, cw, psm	I, v (shed)	- Reg. Dist. malathion spraying program for mosquito control; rotate equipment wash areas throughout rough - only use soap when cleaning for winter
Kamloops	18/SP	>40																								
Kinkora	18/P	5	40										N		well	N	-	N	-	N	g	N	Y	sm, ta, Pl	I, v, scm	- grass clippings from equipment wash area are composted; course is built on sand, therefore, drainage is good
Lacarya	9/P	8	26.325	12.15	0.486	0.486	0.41	8.10	5.103	0.13935	0.0372		N	22 700	pond - gr. water recharge	N	-	Y	O	N	g	N	Y	sm, nw	building new	- use of organic materials (composted turkey manure) has improved strength of turf - did not require herbicides this year
Langara	18/P	68 (rebuilt 1993)	48.00	14.16	1.16	0.84	0.63	14.18	8.10	.40-.81	~.81	~7.3	N	<135 500	well	N	-	Y	O	Y	ss	N	Y	F, H (old); Py, d, F (new)	off-site (Sunset Nurs.)	- only order chemicals as needed; Vancouver Parks Brd. approval required for use of some pesticides
Ledgeview	18/P	~ 30																								
Marine Drive	18/Pr	73	38.90	16.20	0.81	0.81	0.20	20.88				-			city water	N	-	N	-	Y	rough	N	Y	afids, cl, F, Pl	I, v, scm	
Mayfair Lakes	18/SP	6																								
McArthur Island	9/P	3.5	10.94	6.08	0.31	0.31	1.22			0.81		3.24	N		city water	N	-	N	-	N	rock pit	N	Y	Py, sm, ls	workshop	- order chemicals as required - no storage necessary
McCleery	18/P	35 (under renov.)	>44	12.80	1.05	0.68	n/a	26.90	2.00	0.50	0.06	-	N		city water (old); wells (new)	N	-	N	-		ditch	s	Y	psm, F, Py	off-site (Sunset Nurs.)	- Vancouver Parks Board approval required for use of some pesticides

Course	Course Type	Age of Course	Area - total	Area - fairways	Area - greens	Area - tees	Area - water	Area - manicured rough	Area - unmanicured rough	Area - parking lot	Area - clubhouse	Area - other	Documented Management Plan	Annual Irrigation	Irrigation Source	Water Rights Permit	Licenced Volume	Water Quality Monitoring	Requesting Agency	Underdrain Collection System	Equipment Wash Water Drainage	Wash Chemicals Used	Certified Pest Control Manager	Common Pests	Chemical Storage	Comments
		(yrs)					(hectares)							(m³)			(m³/y)									
Meadow Creek	9/P	6																								
Meadow Gardens	18/SP	26 (rebuilt 1994)	64.80	14.18	1.53	1.72	10.13	32.40		4.84		-	N		run-off & Katsie Slough	N	-	N	-	Y	separ. / ditch	s	Y	cl, cf, psm, Py, rt, ta, wasps	l, v, sf, scm	- use cultural methods to treat red thread
Meadowlands	18/SP	>60																								
Mission	9/SP	32	21.87	10.13	0.61	0.41	-	8.10		1.62		0.405	N		Silverdale Ck.	Y		N	-	N	pond	N	Y	ds, F/sm	v, fd	- wash water collected in a dug-out area - water pumped out and clippings composted on a regular basis; all pesticides used are in granular form
Musqueam	18/P	39	~ 15.5	7.70	0.82	0.85	-	2.84		< .80		2.43	N		city water	N	-	N	-	Y	separ./ ss	N	Y	psm	no fd	- control weeds through mowing and spot application of herbicides
Mylora	18/P	18	28.35	16.20	1.62	1.62	1.62	6.48		0.81		-	N	~ 730/d - dry cond.	city water	N	-	N	-	Y (limited on fw)	ditch	N	Y	cl, sm	l, v, scm	- history of organic farming on-site; have found the use of organic fertilizer in fall & spring helps control fungi; use baking soda for control of snow molds; need herbicides once every 5 years
Nicola Valley	9/P	32																								
Oak Tree	9/P	65 (rebuilt 1960)	32.40	16.20	0.46	0.37		12.15	4.05		< .01	-	N		groundwater	N	-	N	-	N	g	N		misc. molds & weeds		- follow RCGA management practices
Pitt Meadows	18/SP	30	44.55										N		Cranberry Slough	Y		Y	O	Y	separator	N	Y	sm	l, v, no fd	- use herbicides for dandelion & clover control every 2/3 yrs; wash area grass clippings spread in rough - water to slough
Point Grey	18/Pr	88	56.66	26.31	1.02	0.74	0.81	26.57		1.21		-	N		city water	N	-	N	-	Y	st	N	Y	psm	l, v	- chemicals are ordered as required; Audobon certification for wildlife & environment
Prince George	18/SP	> 50	47.4863	14.58	1.215	1.0125	1.8225	14.58	10.125	1.215	3.34125		N	272 700	well	N	-	Y	O	N	g	N	Y	sm, reeds, bull rushes	scm, no fd, v	- follow Audobon, CGSA & RCGA management practices; monitor water for algae & aquatic weeds; manage aquatic weeds with mechanical/chemical methods
Quesnel	18/P	39																								
Redwoods	18/P	1	48.195	8.1	1.0935	0.81	0.567	32.4		1.5795		4.779	Y		well	N	-	Y	O	Y	tank	N	Y	cl, d, sm (Py, rt)	scm, l, v	- equipment is pressure washed - water recycled - grass clippings composted; water samples collected 2/y; environmentally sensitive areas fenced
River Ridge	9/P	7	16.20		0.33	0.33	0.81	0.41		0.41		-	N	340/d in summer	pond - ground - water recharge	Y	74 000	N	-	N	n/a		N	sm	barn	- equipment is not washed; only fertilize greens & tees; order pesticides on an as required basis
Riverway	18/P	2	64.8	20.25	1.4864	1.3563	4.05	34.4		3.24		-	N	no meter	city water	N	-	Y	P/M	Y	ss	N	Y	cl, F, ta	l, v, no fd	- herbicide application is contracted out
Royalwood	18/P	5	54.675										N		well	N	-	N	-	Y	tank	N/Y	Y	psm, F, lj, ct	l, no fd	- equipment wash water is pumped to fairways in summer; only use soaps on occasion
Salmon Arm	9/P	67	81										N		Canoe Ck.	Y		N	-	N	wash rack	N	Y	sm, Py, F, d	new storage for 1996	- do not treat for insects and rarely for weeds; waste hauler pumps out wash water from wash rack tank
Sheep Pasture	9/P	10	25	20	1	0.5	-	3.5	-	-	0.01	0.81	N	123 300	storage lagoon for creek water	Y		N	-	N	g	N		none	none	
Shuswap Lake Estates	18/P	18	48.6	25.92	0.8826	0.8826	1.62	12.15	4.05	0.81	0.81	2.43	N	77 300	city water pumped into ponds	N	-	N	-	N	tank/ tile field	N	Y	sm, d	l, no fd, v	- clippings from wash tank cleaned out and composted; in past 3 years have controlled dandelions
Sunshore	9/P	25	19.44	8.5617	0.3443	0.324	0.0203	2.025	7.29	0.405	0.2025	-	N	45 900	city water	N	-	N	-	N	g	N	Y	sm, ls	l, v (shed)	- insect problems are controlled with pruning and some chemicals
Swan-e-set	36/SP	3											Y		pond & canal system	N	-	Y	P	Y	drain	N/Y	Y	cl, F, Py	l, v, scm (ChemLock)	- monthly water quality monitoring for discharge to Pitt R.; wash area grass clippings disposed on hay field - overflow to ponds; use soaps on occasion
Westwood G & C	18/P	1	121.5	10.935	0.8505	1.7415		20.25	40.5	2.025			Y	76 400	pond system & city water	N	-	Y	F	Y	separator	N	Y	psm/F, cl	l, v, scm	- monitor water quality of creeks monthly; sample within 3 days of all pesticide use; wash water collected in 3 stage separator - overflow goes to ditch - grass clippings are composted
Westwood Golf Acad.	9/P	1		4.05	0.6075	0.81		8.91	10.125	0.81			Y		pond system & city water	N	-	Y	F	Y	separator	N	Y	psm/F, cl	l, v, scm	
Williams Lake	18/P	20-25	48.6	20.25	1.215	0.81	< .20	20.25		0.81		0.81	N	~ 2 200/d - dry cond	well	N	-	Y	O	Y	g	N	Y	sm	l, v, no fd	- water monitoring done to investigate pipe scaling problems; generally weeds are not a concern - herbicides last used on fairways 4 years ago

Legend:

General
Y = yes
N = no

Course Type
P = Public
Pr = Private
SP = Semi-Private
# = No. of holes

Management Plans
F = fertilizer management
P = pesticide management
W = water management

Requesting Agency
M = municipal
O = operational requirements
P = provincial
F = federal

Equipment Washing
g = ground
ss = sanitary sewer
st = storm sewer
s = soap

Common Pests
anthr. = anthracnose
blf = broad leaf weeds
bp = brown patch
cf = crane-fly
cl = clover
cat. = catepillars
cw = chickweed
d = dandelion
ds = dollar spot
F = Fusarium
H = Helminthoporum
lj = leatherjackets
ls = leaf spot
nlp = narrow leaf plantain
nw = napweed
Pl = Plantain
psm = pink snow mold
Py = Pythium
rt = red thread
sm = snow molds
ta = take-all patch
th = thistle

Chemical Storage
fd = floor drains
l = locked
sf = sealed floor
scm = spill control measures
v = ventilated

TABLE 2.4
Summary of Fertilizer Use at Fraser River Basin Golf Courses

Course	Fertilizer (trade name)	(formulation)	Form	Recommended Application Rate[4] (kg/100 m^2)	Applications/Year	Amount/Year Nitrogen (kg)					Amount/Year Phosphorous (kg)					Amount/Year Potassium (kg)					Location of Application
						1990	1991	1992	1993	1994	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994	
Aspen Grove	FFII	14-3-3	G	1.55	2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	Super Greens	19-0-17	G	2.32	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	Starter	19-26-5	G	1.76	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	HD Greens	22-0-16	G	2.00	8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	HD Fertilizer + DSB Fungicide	25-0-12	G	0.87	1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	HI Maintenance	32-3-10	G	1.37	2	950	950	950	950	950	89	89	89	89	89	297	297	297	297	297	Tee, Fw
Aquadel	Coast Agri Fertilizer	31-3-10	G		1	422	422	422	422	422	41	41	41	41	41	136	136	136	136	136	Fw, Tee
	Coast Agri Fertilizer	15-5-10	G		7	189	189	189	189	189	63	63	63	63	63	126	126	126	126	126	Gr
	Coast Agri Fertilizer	18-18-18	G	2.07	6	151	151	151	151	151	151	151	151	151	151	151	151	151	151	151	Tee
	Coast Agri Fertilizer	21-0-0	G	1.11	5	42	42	42	42	42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Gr, Tee
	FFII	14-3-3	G	1.55	1	21	21	21	21	21	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	Gr
Belmont	Sustane + Fe	5-2-10	G	4.88	1 - 6	-	-	-	108	17	-		-	43	7	-	-	-	213	36	Gr
	Evergro + quintozene	7-3-12	G	1.50	1 - 2	-	-	-	18	25	-	-	-	8	11	-	-	-	32	43	Gr, Tee
	Evergro	13-26-6	G	1.95	1-3	-	-	-	244	1173	-	-	-	488	2346	-	-	-	113	541	Tee, Fw, R
	Par Ex	14-14-14	G	3.42	3	-	-	-	149	-	-	-	-	149	-	-	-	-	149	-	Gr
	Par Ex	16-4-16	G	2.93	1	-	-	-	57	57	-	-	-	14	14	-	-	-	57	57	Gr
	Par Ex	20-0-20	G	2.44	3 - 6	-	-	-	142	312	-	-	-	0	0	-	-	-	142	312	Gr, Tee
	Ammonium Sulphate	21-0-0	G	1.11	1	-	-	-	25	49	-	-	-	0	0	-	-	-	0	0	Gr, Tee
	Par Ex	21-4-21	G	2.57	2 - 4	-	-	-	1880	67	-	-	-	359	13	-	-	-	1880	67	Tee, Fw, R
	Par Ex	32-3-8	G	1.54	2 -3	-	-	-	763	2456	-	-	-	72	230	-	-	-	191	614	Tee, Fw, R
Carnoustie (Burns L.)	FFII	14-3-3	G	1.55	2	22.2	22.2	22.2	22.2	22.2	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	Gr
	HD Fertilizer & DSB Fungicide	25-0-12	G	0.87	1	11.1	11.1	11.1	11.1	11.1	0.0	0.0	0.0	0.0	0.0	5.3	5.3	5.3	5.3	5.3	Gr
	Starter	19-26-5	G	1.76	1	23.9	23.9	23.9	23.9	23.9	32.7	32.7	32.7	32.7	32.7	6.3	6.3	6.3	6.3	6.3	Gr, Tee
	HD Super Greens	19-0-17	G	2.32	1	21.5	21.5	21.5	21.5	21.5	0.0	0.0	0.0	0.0	0.0	19.2	19.2	19.2	19.2	19.2	Gr
	HD Fertilizer + 7.27 % Mn	22-0-12	G	2.09	1	16.4	16.4	16.4	16.4	16.4	0.0	0.0	0.0	0.0	0.0	10.7	10.7	10.7	10.7	10.7	Gr
	HD Greens	22-0-16	G	2.00	2	44.9	44.9	44.9	44.9	44.9	0.0	0.0	0.0	0.0	0.0	22.0	22.0	22.0	22.0	22.0	Gr
	High "K"	15-0-28	G	1.62	2	29.9	29.9	29.9	29.9	29.9	0.0	0.0	0.0	0.0	0.0	55.9	55.9	55.9	55.9	55.9	Gr, Tee
	Turf Fertilizer	33-3-6	G	1.32	1	11.8	11.8	11.8	11.8	11.8	1.1	1.1	1.1	1.1	1.1	2.2	2.2	2.2	2.2	2.2	Tee
	Fertilizer + Iron Poly-S	25-3-10	G	1.76	2	18.0	18.0	18.0	18.0	18.0	2.2	2.2	2.2	2.2	2.2	7.2	7.2	7.2	7.2	7.2	Tee
Central Park	Par Ex	16-24-12	G	1.81	1-2	-	-	-	38.4	25.6	-	-	-	57.6	38.4	-	-	-	2880.0	19.2	Gr
	Sustane	5-2-10	G	4.50	2	-	-	-	-	22.0	-	-	-	-	8.8	-	-	-	-	44.0	Gr
	Par Ex	16-4-16	G	2.93	2	-	-	-	38.4	51.2	-	-	-	9.6	12.8	-	-	-	38.4	51.2	Gr
	Par Ex	20-0-20	G	2.44	3	-	-	-	72.0	80.0	-	-	-	0.0	0.0	-	-	-	72.0	80.0	Gr
	Par Ex	24-4-12	G	2.00	2	-	-	-	960.0	960.0	-	-	-	160.0	160.0	-	-	-	480.0	480.0	Fw, R
	Par Ex	21-4-21	G	2.57	1	-	-	-	420.0	420.0	-	-	-	80.0	80.0	-	-	-	420.0	420.0	Fw, R
	CIL Sulphur Coated Urea	16-32-6	G	1.36	2	25.6	25.6	25.6	-	-	51.2	51.2	51.2	-	-	9.6	9.6	9.6	-	-	Gr
	CIL SCU	20-0-20	G	2.27	3	72.0	72.0	72.0	-	-	0.0	0.0	0.0	-	-	72.0	72.0	72.0	-	-	Gr
	CIL SCU	20-5-15	G	2.27	3	72.0	72.0	72.0	-	-	18.0	18.0	18.0	-	-	54.0	54.0	54.0	-	-	Gr
	CIL SCU	28-4-8	G	1.62	3	1680.0	1680.0	1680.0	-	-	240.0	240.0	240.0	-	-	480.0	480.0	480.0	-	-	Fw, R
	CIL SCU	6-0-36	G	1.36	2	14.4	14.4	14.4	-	-	0.0	0.0	0.0	-	-	86.4	86.4	86.4	-	-	Gr
Cultus	CIL	25-4-10	G	1.81					x					x					x		
	CIL	15-0-30	G	1.36					x					x					x		
	CIL	16-32-6	G	1.54					x					x					x		
	CIL	10-2-2	G	4.50					x					x					x		
	CIL	20-5-15	G	2.27					x					x					x		
	CIL	20-0-20	G	2.27					x					x					x		
	CIL	6-0-36	G	1.36					x					x					x		
	FFII	14-3-3	G	1.55						x					x					x	
	HD Super Greens	19-0-17	G	2.32						x					x					x	
	Starter	19-26-5	G	1.76						x					x					x	
	HD NPK Greens	21-3-21	G	2.09						x					x					x	
	HD Fertilizer + 7.27% Mn	22-0-12	G	2.09						x					x					x	
	HD Greens	22-0-16	G	2.00						x					x					x	
	HD Super Fairway	35-3-7	G	1.87						x					x					x	
	HD Nit/Pot Fairway	22-0-22	G	2.00						x					x					x	
	Fertilizer + Iron Poly-S	25-3-10	G	1.76						x					x					x	
	Step (Trace Element Package)	(micronutrients)	G		1																

Course	Fertilizer		Form	Recommended Application Rate[4]	Applications/Year	Amount/Year Nitrogen (kg)					Amount/Year Phosphorous (kg)					Amount/Year Potassium (kg)					Location of Application
	(trade name)	*(formulation)*		*(kg/100 m^2)*		*1990*	*1991*	*1992*	*1993*	*1994*	*1990*	*1991*	*1992*	*1993*	*1994*	*1990*	*1991*	*1992*	*1993*	*1994*	
Fort Langley[1]	FFII	14-3-3	G	1.55	8					71.2					15.3					15.3	Gr, Tee
	High "K" + Micronutrients	15-0-28	G	1.62	5					67.2					0.0					125.5	Gr, Tee
	NPK Greens + Micronutrients	18-9-18	G	2.04	3					48.7					24.3					48.7	Gr
	Starter	19-26-5	G	1.76	3					58.1					79.6					15.3	Tee
	Super Greens	19-0-17	G	2.32	3					49.5					0.0					44.3	Gr
	HD NPK Greens	21-3-21	G	2.09	2					80.9					11.6					80.9	Gr
	HD Fertilizer + 7.27% Mn	22-0-12	G	2.09	2					33.0					0.0					18.0	Gr
	HD Greens	22-0-16	G	2.00	6					134.6					0.0					97.9	Gr
	HD Nit/Pot Fairway	22-0-22	G	2.00	3					94.2					0.0					94.2	Tee
	HD Fertilizer + DSB Fungicide	25-0-12	G	0.87	2					26.6					0.0					12.7	Gr
	Turf Fertilizer + Iron	25-3-10	G	3.89	1					990.0					118.8					396.0	Fw
	Fertilizer + 1.7% Iron	29-3-6	G	1.56	1					4.6					0.5					1.0	Gr
	HD Fertilizer + Dicot III	32-4-3	G	1.37	1					719.4					89.9					67.4	Fw
	Turf Fertilizer	33-3-6	G	13.18	1					708.8					64.4					128.9	Fw
	HD Super Fairway	35-3-7	G	1.87	2					93.6					93.6					187.2	Tee
Lacarya	Nutralane	8-0-42	G	1.10	1				240.0	240.0				0.0	0.0				1260.0	1260.0	Fw, R
	Nutri-K Min	5-0-41	G		1				13.8	11.3				0.0	0.0				112.8	92.3	
		11-22-14	G		1				30.8	13.2				61.6	26.4				39.2	16.8	Gr, Tee
	Sustane +	10-2-10	G		2-3				64.0	30.0				12.8	6.0				64.0	6.0	Gr, Tee
		19-3-18	G		6				-	76.0				-	12.0				-	72.0	
		24-4-12	G	2.00	2				1500.0	1320.0				250.0	220.0				750.0	660.0	Gw, R
		15-3-19	G		4				78.0	12.0				15.6	2.4				98.8	15.2	
Langara[2]	Sustane + Fe	5-2-10	G	4.88	4					97.6					39.0					195.2	Gr, Tee
	Par Ex	14-14-14	G	3.42	3					168.0					168.0					168.0	Gr
	Par Ex	16-4-16	G	2.93	1					54.4					13.6					54.4	Gr
	Evergro, 40% S.C.U.	18-18-18	G	2.00	2					1008.0					1008.0					1008.0	Fw, R
		19-19-19	G	2.44	1					38.0					38.0					38.0	Tee
	Par Ex	20-0-20	G	2.44	2					112.0					0.0					112.0	Gr
	W/S	21-0-0	G	1.22	3					84.0					0.0					0.0	Gr, Tee
	Evergro	23-3-23	G	2.44	3					110.4					14.4					110.4	Tee
	Evergro, 40% ESN	23-3-23	G	1.5-1.7	2					1044.2					136.2					1044.2	Fw, R
	Par Ex	24-4-12	G	2.00	1					672.0					112.0					336.0	Fw
	Evergro, 40% ESN	30-3-15	G	1.90	2					1440.0					144.0					720.0	Fw, R
McCleery	FFII	14-3-3	G	1.55		71.1	71.1	71.1	71.1	71.1	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	15.2	
	High K Minors	15-0-28	G	1.62		42.3	42.3	42.3	42.3	42.3	0.0	0.0	0.0	0.0	0.0	79.0	79.0	79.0	79.0	79.0	
	HD Super Greens	19-0-17	G	2.32		76.0	76.0	76.0	76.0	76.0	0.0	0.0	0.0	0.0	0.0	68.0	68.0	68.0	68.0	68.0	
	NPK Turf Fertilizer	21-3-20	G	2.09		556.7	556.7	556.7	556.7	556.7	79.5	79.5	79.5	79.5	79.5	530.2	530.2	530.2	530.2	530.2	
	HD NPK Greens	21-3-21	G	2.09		76.0	76.0	76.0	76.0	76.0	10.9	10.9	10.9	10.9	10.9	76.0	76.0	76.0	76.0	76.0	
	HD Fertilizer + 7.27% Mn	22-0-12	G	2.09		55.9	55.9	55.9	55.9	55.9	0.0	0.0	0.0	0.0	0.0	30.5	30.5	30.5	30.5	30.5	
	HI Maintenance	32-3-10	G	1.37		80.6	80.6	80.6	80.6	80.6	7.6	7.6	7.6	7.6	7.6	25.2	25.2	25.2	25.2	25.2	
Mission	HD Greens	22-0-16	G	2.00		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	Super Greens	19-0-17	G	2.32		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	Starter	19-26-5	G	1.76		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	Turf Starter	16-25-12	G	1.95		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	High K Minors	15-0-28	G	1.62		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	FFII	14-3-3	G	1.55		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	NPK Turf Fertilizer	21-3-20	G	2.09		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr, Tee
	HD Super Fairway	35-3-7	G	1.87		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Fw
	HI Maintenance	32-3-10	G	1.37		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Fw

Course	Fertilizer		Form	Recommended Application Rate[4]	Applications/Year	Amount/Year Nitrogen (kg)					Amount/Year Phosphorous (kg)					Amount/Year Potassium (kg)					Location of Application
	(trade name)	(formulation)		(kg/100 m²)		1990	1991	1992	1993	1994	1990	1991	1992	1993	1994	1990	1991	1992	1993	1994	
Musqueam	Par Ex	18-26-12	G					x					x					x			
	Par Ex Slow Release	16-4-16	G	2.93				x	x				x	x				x	x		
	Par Ex Slow Release	15-5-10	L					x					x					x			
	Par Ex Slow Release	20-0-20	G	2.44				x	x	x			x	x	x			x	x	x	
	Evergro	25-4-8	G	1.81				x	x	x			x	x	x			x	x	x	
	Par Ex	12-3-34	G	1.36				x	x	x			x	x	x			x	x	x	
	Par Ex	30-3-15	G	1.55				x		x			x		x			x		x	
	Par Ex	32-3-8	G	1.54				x					x					x			
	Sustane + Fe	5-2-10	G	4.88						x					x					x	
	Par Ex	10-3-30	G	1.55						x					x					x	
	Evergro	15-5-7	G	2.70						x					x					x	
	Par Ex	24-4-12	G	2.00					x					x					x		
	Par Ex	16-24-12	G	1.81				x	x	x			x	x	x			x	x	x	
	Plant-Prod	20-8-20	L																		
	Plant-Prod	35-5-10	L																		
	Par Ex	14-14-14	G	3.42																	
Oak Tree	Burgess Feeds	21-0-0	G	1.10		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Gr
	Burgess Feeds	32-8-8	G	1.55		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Fw, Tee
	2 + 2		G			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Prince George	Starter	19-26-5	G	1.76			x	x	x	x		x	x	x	x		x	x	x	x	
	HD Nit/Pot Fairway	22-0-22	G	2.00			x	x	x	x		x	x	x	x		x	x	x	x	
	HD Greens	22-0-16	G	2.00			x	x	x	x		x	x	x	x		x	x	x	x	
	HD NPK Greens	21-3-21	G	2.09			x	x	x	x		x	x	x	x		x	x	x	x	
	Turf Starter	16-25-12	G	1.95			x	x	x	x		x	x	x	x		x	x	x	x	
	Fertilizer + 1.7% Iron	29-3-6	G	1.55			x	x	x	x		x	x	x	x		x	x	x	x	
	HI Maintenance	32-3-10	G	1.37			x	x	x	x		x	x	x	x		x	x	x	x	
	HD Fertilizer + DSB Fungicide	25-0-12	G	0.87			x	x	x	x		x	x	x	x		x	x	x	x	
	FFII	14-3-3	G	1.55			x	x	x	x		x	x	x	x		x	x	x	x	
River Ridge		13-16-10			~ 6																Gr, Tee
Riverway[3]	Par Ex	16-24-2	G	1.81	2-5				134.4	54.4				201.6	81.6				100.8	40.8	Gr, Tee
	Par Ex	16-4-16	G	2.93	4				160.0	169.6				40.0	42.4				160.0	169.6	Gr, Tee
	Sustane	5-2-10	G	4.50	4				-	76.0				-	30.4				-	152.0	Gr, Tee
	Par Ex	20-0-20	G	2.44	4				136.0	160.0				0.0	0.0				136.0	160.0	Gr, Tee
	Par Ex	21-4-21	G	2.57	6				277.2	277.2				52.8	52.8				277.2	277.2	Tee
	Evergro + ESN	13-26-6	G		1-2				343.2	312.0				686.4	624.0				158.4	144.0	Fw, R
	Par Ex	24-4-12	G	2.00	2				768.0	1440.0				128.0	240.0				384.0	720.0	Fw, R
	Evergro + ESN	23-3-23	G	1.5-1.7	3				-	1775.6				-	231.6				-	1775.6	Fw, R
	Sustane	5-2-4	G	4.89	2				34.0	-				13.6	-				27.2	-	Gr, Tee
	Par Ex	32-3-8	G	1.54	1				256.0	-				24.0	-				64.0	-	Fw, R
Sheep Pasture		16-20-4	G						17.3	17.3				21.6	21.6				4.3	4.3	
Shuswap L. Estates	Cominco	13-16-10	G	1.85	4	21.3					26.2					16.4					Fw, Ap, Tee
	Cominco	46-0-0	G	0.86 - 1.36	4	75.3					0.0					0.0					Fw, Ap, Tee
	Starter	19-26-5	G	1.76	7	230.1	230.1	230.1	230.1	230.1	314.9	314.9	314.9	314.9	314.9	60.6	60.6	60.6	60.6	60.6	Gr
	Greens	22-0-16	G	2.00	7	45.1	45.1	45.1	45.1	45.1	0.0	0.0	0.0	0.0	0.0	193.8	193.8	193.8	193.8	193.8	Gr
	FFII	14-3-3	G	1.55	2	36.4	36.4	36.4	36.4	36.4	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	Gr
	Agrico Fertilizer	23-3-23	G	2.44	1	-	9.4	9.4	9.4	9.4	-	1.2	1.2	1.2	1.2	-	9.4	9.4	9.4	9.4	Fw, Ap, Tee
	Agrico Fertilizer	30-3-15	G	1.55	2	-	24.5	24.5	24.5	24.5	-	2.5	2.5	2.5	2.5	-	12.3	12.3	12.3	12.3	Fw, Ap, Tee
	Agrico Fertilizer	10-3-30	G	1.55	1	-	4.1	4.1	4.1	4.1	-	1.2	1.2	1.2	1.2	-	13.3	13.3	13.3	13.3	Fw, Ap, Tee
Sunshore	Coast Agri Micro	19-3-18	G		2	22.8	22.8	22.8	22.8	22.8	3.6	3.6	3.6	3.6	3.6	21.6	21.6	21.6	21.6	21.6	Gr, Ap
	Coast Fore-N	21-6-13	G		1	404.3	404.3	404.3	404.3	404.3	115.5	115.5	115.5	115.5	115.5	250.3	250.3	250.3	250.3	250.3	Tee, Fw
	Greens	22-0-16	G	2.00	4	52.8	52.8	52.8	52.8	52.8	0.0	0.0	0.0	0.0	0.0	38.4	38.4	38.4	38.4	38.4	Gr, Ap
	Plant Prod	35-3-10	L		2	21.0	21.0	21.0	21.0	21.0	1.8	1.8	1.8	1.8	1.8	6.0	6.0	6.0	6.0	6.0	Gr, Ap
	Pro Tour Evergro	30-3-15	G	1.55	1	121.9	121.9	121.9	121.9	121.9	12.2	12.2	12.2	12.2	12.2	60.9	60.9	60.9	60.9	60.9	Fw, Tee

Legend: G = granular L = liquid Ap = aprons Fw = fairways Gr = greens R = rough

Note:

[1] Fertilizer program only available for 1995 (new superintendent on-site).

[2] Course rebuilt for 1994 season. Special fertilizer program was used for grow in of new turf; therefore, program is higher than normal in synthetic fertilizers.

[3] Fertilizer use increased in the 1994/95 season due to the construction of an additional 7 holes.

[4] Recommended application rates obtained from local suppliers.

"x" Denotes fertilizer applied, but quantity unknown.

"-" Denotes fertilizer type not applied in this year.

TABLE 2.5
Summary of Pesticide Use at Fraser River Basin Golf Courses

Course	Pesticide		Biological Activity	Form	Applications/Year	Amount/Year (active ingredient) 1990	Amount/Year (active ingredient) 1991	Amount/Year (active ingredient) 1992	Amount/Year (active ingredient) 1993	Amount/Year (active ingredient) 1994	Amount/Year (active ingredient) 1995	Location of Application	Target
	(active ingredient)	*(trade name)*				*(kg)*	*(kg)*	*(kg)*	*(kg)*	*(kg)*	*(kg)*		
Aspen Grove	chloroneb	Fungicide V	F	G		x	x	x	x	x	x		sm
	dicamba	Killex	H	L									cl, d
	glyphosate	Wrangler	H	L									th
	mecoprop	Killex	H	L									cl, d
	quintozene	FFII	F	G		x	x	x	x	x	x		sm
	thiophanate-methyl	DSB Fungicide	F	G		x	x	x	x	x			ds
	2,4-D	Killex	H	L									cl, d
Aquadel	benomyl	Benlate	F	P	2	6.0	6.0	-	-	-	-	Gr	F
	dicamba	Tri-Kill	H	L	1	-	0.9	-	0.9	-	-	Fw	weeds
	mancozeb	Manzate 200 DF	F	P	1-3	-	9.0	9.0	13.5	4.5	-	Gr	F
	mecoprop	Tri-Kill	H	L	1	-	5.0	-	5.0	-	-	Fw	weeds
	quintozene	FFII	F	G	1	23.1	23.1	23.1	23.1	23.1	-	Gr	sm
	quintozene	Folosan	F	P	2	9.0	9.0	9.0	9.0	9.0	-	Gr	sm, Py
	2,4-D	Tri-Kill	H	L	1	-	9.5	-	9.5	-	-	Fw	weeds
Belmont	quintozene	Evergro	F	G	1-2	-	-	-	40.0	54.6		Gr, Tees	psm
	dicamba	Killex	H	L									
	mecoprop	Killex	H	L									
	2,4-D	Killex	H	L	1	-	-	-	-	x		Fw	cl
Big Sky	chlorothalonil	Daconil 2787	F	L									
	dicamba	Killex	H	L									
	ghlyphosate	Roundup	H	L									
	iprodione	Rovral	F	L								Fw, Gr	ds, bp, ls, sm
	mecoprop	Killex	H	L									
	quintozene	FFII	F	G								Gr	sm
	quintozene	Terrachlor	F	P								Fw, Gr	sm
	2,4-D	Killex	H	L									
Carnoustie (Burns L.)	chloroneb	Fungicide V	F	G	1	9.3	9.3	9.3	9.3	9.3	9.3	Gr	
	iprodione	Fungicide X	F	G	1	1.6	1.6	1.6	1.6	1.6	1.6	Gr	
	quintozene	FFII	F	G	2	24.5	24.5	24.5	24.5	24.5	24.5	Gr	
	thiophanate-methyl	DSB Fungicide	F	G	1	0.8	0.8	0.8	0.8	0.8	0.8	Gr	
	micro-nutrients	Step (Trace Elements)	-	-	1	x	x	x	x	x	x	Gr	

Course	**Pesticide**		**Biological Activity**	**Form**	**Applications/Year**	**Amount/Year (active ingredient) 1990**	**Amount/Year (active ingredient) 1991**	**Amount/Year (active ingredient) 1992**	**Amount/Year (active ingredient) 1993**	**Amount/Year (active ingredient) 1994**	**Amount/Year (active ingredient) 1995**	**Location of Application**	**Target**
	(active ingredient)	***(trade name)***				***(kg)***	***(kg)***	***(kg)***	***(kg)***	***(kg)***	***(kg)***		
Central Park	mancozeb	Manzate	F	P	2-6	-	16.5	37.5	15.0	56.3		Gr	F, algae
	benomyl	Benlate	F	P	2-5	-	18.0	6.0	-	-		Gr	bp, F
	iprodione	Rovral	F	L	1-4	x	2.0	2.5	6.7	9.7		Gr	bp, ds, F
	chlorothalonil	Daconil 2787	F	L	1-2	-	-	-	4.4 L	8.1 L		Gr	bp, ds
	thiophanate-methyl	Easout	F	P	1-6	21.4	6.3	16.8	13.7	20.0		Gr	F, sm, antra.
	thiophanate-methyl	Scotts Systemic Fung.	F	G	1-4	-	3.1	-	4.2	1.2		Gr	sm
	quintozene	FFII	F	G	1-2	6.2	20.8	9.7				Gr	sm
	mancozeb	Dithane M45	F	P	5	29.2	-	-	-	-		Gr	algae, F
	mancozeb	Dithane D.G.	F	P	5	-	45.0	-	-	-		Gr	algae, F
Cultus	quintozene	FFII	F	G	3	-	-	-	37.7	37.7	-	Gr	
Eighteen Pastures	glyphosate	Roundup	H	L									
Fort Langley	dicamba	Dicot III	H	G	1						1.8	Fw	
	iprodione	Fungicide X	F	G	2						7.0	Gr	
	mecoprop	Dicot III	H	G	1						13.7	Fw	
	quintozene	FFII	F	G	8						105.0	Gr, Tee	
	thiophanate-methyl	DSB Fungicide	F	G	2						1.9	Gr	
	thiophanate-methyl	Systemic Fungicide	F	G	2						1.9	Gr	
	2,4-D	Dicot III	H	G	1						27.7	Fw	
Lacarya	chlorothalonil	Daconil 2787	F	L	8-10				44.0 L	40.2 L	37.6 L	Gr, Tee	H, bp psm, gsm
	iprodione	Rovral 50W	F	P	1-3				5.8	5.0	4.0	Gr	H
	iprodione	Rovral Green	F	L	1				2.5	-	-	Gr	H
	quintozene	Terrachlor	F	P	1-5				36.8	-	12.8		gsm, psm, bp
	chloroneb	Terraneb	F	P	5				13.3	-	-		Py
	dicamba	ParIII	H	L	1				0.02	-			d, pl, blw
	mecoprop	ParIII	H	L	1				1.0	-			d, pl, blw
	2,4-D	Par III	H	L	1				1.9	-			d, pl, blw
	MCPA	MCPA Amine 500	H	L	1				8.5	-	-		d, pl, blw
Langara	benomyl	Benlate	F	P	1	10.0	-	-	-	-		Gr	
	chlorothalonil	Bravo	F	L	1	4.6 mL	-	-	-	-		Gr	
	dicamba	Banvel	H	L	1	-	-	-	-	6.0		Fw	cl
	etridiazole	Truban	F		1	-	-	-	5.4	-		Gr	Py
	mancozeb	Dithane M-45	F	P	1	x	-	-	-	-		Gr	
	maneb	Manzate	F	P	2 - 5	57.0	40.0	100.0	-	-		Gr	
	mecoprop	Mecoprop	H	L	1	-	-	-	-	48.0		Fw	cl
	metalaxyl	Ridomil	F	L	1	-	-	-	1.9	-		Gr	
	quintozene	FFII	F	G	1 - 2	-	42.0	-	-	18.0		Gr	F

Course	Pesticide		Biological Activity	Form	Applications/Year	Amount/Year (active ingredient) 1990	Amount/Year (active ingredient) 1991	Amount/Year (active ingredient) 1992	Amount/Year (active ingredient) 1993	Amount/Year (active ingredient) 1994	Amount/Year (active ingredient) 1995	Location of Application	Target
	(active ingredient)	*(trade name)*				*(kg)*	*(kg)*	*(kg)*	*(kg)*	*(kg)*	*(kg)*		
McCleery	chloroneb	Fungicide V	F	G	1	-	-	-	3.8	18.6		Gr, A	
		Terraneb	F	L	1	-	-	-	12.0	-		Gr, A	
	glyphosate	Roundup	H	L	1	x	x	x	x	-		Tr (base)	
	quintozene	FFII	F	G	4	78.2	78.2	78.2	78.2	78.2		Gr, A	
	thiophanate-methyl	Systemic Fungicide	F	G	1	-	-	-	-	2.5		Gr, A	
Meadow Gardens	chloroneb		F									Gr	Py
	diazinon		I										crane-fly
	dicamba	Killex	H	L									cl
	maneb	Manzate	F	P									psm
	mecoprop	Killex	H	L									cl
	quintozene		F										psm
	thiophanate-methyl		F										ta
	2,4-D	Killex	H	L									cl
Mission	quintozene	FFII	F	G		x	x	x	x	x		Gr	psm, ds, F
	thiophanate-methyl	DSB Fungicide	F	G		x	x	x	x	x		Gr	psm, ds, F
Musqueam	chlorothalonil	Daconil 2787	F	L	1 - 4	-	13.7 L	20.6 L	23.0 L	5.9 L	-	Gr	psm
	chlorothalonil	Bravo	F	P	1	-	x	-	-	-	-	Gr	psm
	iprodione	Rovral	F	L	2-3	-	20.0	15.0	11.3	2.8	-	Gr	psm
	iprodione	Fungicide X	F	G	3	-	-	-	-	2.0	-	Gr	psm
	mancozeb	Dithane M-45	F	P	3	-	54.4	-	-	-	-	Gr	psm
	mancozeb	Manzate 200 DF	F	P	2 - 3	-	40.5	17.3	-	-	-	Gr	psm
	quintozene	Plant-Prod	F		1 - 10	-	13.9	117.8	67.5	73.8	-	Gr	psm
	thiophanate-methyl	DSB Fungicide	F	G	2 - 5	-	-	-	0.8	2.2	-	Gr	psm
Oak Tree	benomyl		F	P	2	x	x	x	x	x	x	Gr	molds
	glyphosate	Roundup	H	L	2	1.1	1.1	1.1	1.1	1.1	1.1	P	
	mancozeb	Dithane M-45	F	P	3	x	x	x	x	x	x	Gr	molds
	quintozene		F	G	2	x	x	x	x	x	x	Gr	molds
Point Grey	chloroneb		F									Gr	F
	quintozene	FFII	F	G	5							Gr	F
Prince George	chloroneb	Fungicide V	F	G		-	-	x	x	x	-		
	glyphosate	Roundup	H	L	1	-	-	-	-	3.6	-		
	dicamba	Trillion	H	L	1	-	-	-	-	x	-	Fw	cl, d
	quintozene	FFII	F	G		-	-	x	x	x	-	P	gr, weeds
	thiophanate-methyl	DSB Fungicide	F	G		-	-	x	x	x	-		
River Ridge	quintozene	FFII	F	G	1								
	chloroneb		F		1								

Course	Pesticide (active ingredient)	Pesticide (trade name)	Biological Activity	Form	Applications/Year	Amount/Year (active ingredient) 1990 (kg)	Amount/Year (active ingredient) 1991 (kg)	Amount/Year (active ingredient) 1992 (kg)	Amount/Year (active ingredient) 1993 (kg)	Amount/Year (active ingredient) 1994 (kg)	Amount/Year (active ingredient) 1995 (kg)	Location of Application	Target
Riverway[1]	benomyl	Benlate	F	P	1-5				5.0	19.0		Gr	ta
	iprodione	Rovral	F	L	2-3				4.3	5.8		Gr	bp, ds, F
	thiophantate-methyl	Easout	F	P	1				2.1	14.7		Gr	F, sm
	thiophanate-methyl	Scotts Systemic Fung.	F	G	4				3.6	-		Gr	sm
	mancozeb	Manzate	F	P	2				15.0	15.0		Gr	F, algae
	chlorothalonil	Daconil 2787	F	L	3				28.3 L	-		Gr	bp, ds
Shuswap L. Estates	chloroneb	Fungicide V	F	G	1-2	10.8	10.8	10.8	21.6	10.8	-	Gr	psm
	quintozene	FFII	F	G	2	40.0	40.0	40.0	40.0	40.0	-	Gr	psm
	thiophanate-methyl	Systemic Fungicide	F	G	1	-	-	3.0	3.0	3.0	-	Gr	gsm
Sunshore	benomyl	Benlate	F	L	1	2.0	2.0	2.0	2.0	2.0	-	Gr	molds, ls
	chloroneb	Fungicide V	F	G	1	2.8	2.8	2.8	2.8	2.8	-	Gr	molds
	chlorothalonil	Daconil 2787	F	L	1	0.4 L	0.4 L	0.4 L	0.4 L	0.4 L	-	Gr	ls
	diazinon	Green Cross	I	L	3	0.06 L	0.06 L	0.06 L	0.06 L	0.06 L	-	Tr, Fl	aph., cat.
	dicamba	Tri-Kill	H	L		0.2	0.2	0.2	0.2	0.2	-	Fw, Tee, R	weeds
	glyphosate	Roundup	H	L	3	0.1	0.1	0.1	0.1	0.1	-	P	weeds
	iprodione	Rovral	F	L	2	2.5	2.5	2.5	2.5	2.5	-		
	mancozeb	Manzate 200 DF	F	P	3	30.0	30.0	30.0	30.0	30.0	-	Gr	ls
	mecoprop	Tri-Kill	H	L		1.0	1.0	1.0	1.0	1.0	-	Fw, Tee, R	weeds
	quintozene	Terrachlor	F	P	2	x	x	x	x	x	-	Gr, Tee	
	2,4-D	Tri-Kill	H	L		1.9	1.9	1.9	1.9	1.9	-	Fw, Tee, R	weeds

Legend:

Activity
F = fungicide
H = herbicide
I = insecticide

Form
L = liquid
G = granular
P = powder

Appl. Location
A = aprons
Fw = fairways
Gr = greens
Fl = flowers
P = paths
R = rough
Tr = trees

Targets
anthr. = anthracnose
aph. = aphids
blw = broad leaf weeds
bp = brown patch
cat. = catepillars
cl = clover
d = dandelions
ds = dollar spot
F = Fusarium
gr = grasses
gsm = grey snow mold
H = Helmintosporim
ls = leaf spot
p= plantain
psm = pink snow mold
Py = Pythium
sm = snow mold
ta = take-all patch

"X" denotes pesticide applied, but quantity unknown
"-" denotes pesticide not applied in this year

[1] Fertilizer & fungicide use increased in the 1994/95 seasons due to the construction of an additional 7 holes.

TABLE 2.6
Summary of Pesticide Characteristics

	Pesticide		PCP Number	Biological Activity	Form	Fraction Active Ingredient	Recommended Application Rate	Target (literature)		Toxicity	
(active ingred.)	*(trade name)*	*(manufacturer)*					*(kg/m^2)*		*(mammals)*	*(birds)*	*(fish)*
benomyl	Benlate	DuPont	11062	F	P	50%	no turf use	F, rt, ds	LD50>10 000 mg/kg (rats, acute oral) LD50>10 000 mg/kg (rabbits, acute percutaneous)	LC50>500 mg/kg diet (mallarc ducks & bobwhite quail, 8d dietary)	96h LC50 = 0.17 mg/L (rainbow trout) 96h LC50 = 4.2 mg/L (goldfish)
chloroneb	Fungicide V	Scotts	11466	F	G	6.25%	14.86 kg/1000 m^2	sm, Py	LD50>11 000 mg/kg (rats, acute oral) LD50>5 000 mg/kg (rabbits, acute percutaneous)	LD50>5000 mg/kg (mallard ducks & Japanese quail)	46h LC50 > 4200 mg/L (bluegill sunfish)
	Terraneb	Kincaid	10886	F	L	65%	0.125 - 0.275/100				
chlorothalonil	Bravo	SDS Biotech	15723	F	L	40.40%	no turf use	range of fungal diseases (ie. bp, anthra., ds, F, sm, H)	LD50>10 000 mg/kg (rats, acute oral) LD50>5 000 mg/kg (dogs, acute oral) LD50>10 000 mg/kg (rabbits, acute percutaneous)	LC50>5 200 mg/kg diet (bobwhite quail) LC50>21 500 mg/kg diet (mallard ducklings) (8 d dietary)	LC50 = 0.25 mg/L (rainbow trout) LC50 = 0.38 mg/L (bluegill sunfish) LC50 = 0.43 mg/L (channel catfish)
	Daconil 2787	SDS Biotech	15724	F	L	40.40%	95-500 mL/100 m^2				
diazinon	Diazinon	Green Cross	10914	I	L	12.50%	3-6 mL/L @ 5-12L/m^2	sucking & chewing insects & mites	LD50=240-480 mg/kg (rats, acute oral) LD50>2150 mg/kg (rats, acute percutaneous)	LD50=3.5 mg/kg (mallard ducklings, acute oral) LD50=4.2 mg/kg (young pheasants, acute oral)	96 h LC50 = 16 mg/L (bluegill sunfish) 96h LC50 = 2.6-3.2 (rainbow trout)
dicamba	Banvel	Sandoz	18837	H	L	480 g/L	1.5 L/10 000 m^2	broad-leaf weeds	LD50>1707 mg/kg (rats, acute oral) LD50>2000 mg/kg (rabbits, acute percutaneous)	LC50>10000 mg/kg diet (mallard ducks & bobwhite quail, 8d dietary) LD50>2000 mg/kg (acute oral, mallard ducks)	96h LC50 = 28 mg/L (rainbow trout) 96h LC50 = 23 mg/L (bluegill sunfish)
	Dicot III	Scotts	841422C	H	G	0.08%	28.1/2044				
	Killex	Green Cross	8811	H	L	18 g/L	60 mL/5-10 L H_2O/100 m^2				
	Par III	United Agri Products	19810	H	L	18 g/L	30-60 mL/100 m^2 in suff. H_20				
	Trillion	Plant Products	18963	H	L	18 g/L	60 mL/100 m^2 in 10 L H_20				
	Tri-Kill	Sanex	19400	H	L	18 g/L	60 mL/100 m^2				
etridiazole	Truban	Mallinckrodt	11460	F	P	30%	no turf use	Ph, Py	LD50>1100 mg/kg (male rats, acute oral)	-	24h LC50 > 4 mg/L (rainbow trout) 24h LC50 > 7.5 mg/L (blue gill sunfish)
glyphosate	Roundup	Monsanto, Schering	13644	H	L	356 g/L	2.5 - 12.4 L/ha	blw, gr	LD50>5600 mg/kg (rats, acute oral) LD50>5000 mg/kg (rabbits, acute percutaneous) 4h LC50>12.2 mg/L air (rats, acute inhalation)	LD50>3850 mg/kg (bobwhite quail, acute oral) LC50>4640 mg/kg diet (ducks & quail, 8d dietary)	96h LC50>86 mg/L (trout) 96h LC50>120 mg/L (bluegill sunfish)
	Wrangler	Van Waters & Rogers	20862	H	L	356 g/L	1-2% solution				
iprodione	Fungicide X	Scotts	23494	F	G	1.30%	52.9/1022	C, F, B, H, M (bp, ds, ls, F, sm, H)	LD50>3500 mg/kg (rats, acute oral) LD50>2500 mg/kg (rats, acute percutaneous) LD50>1000 mg/kg (rabbits, acute percutaneous)	LD50=930 mg/kg (bobwhite quail, acute oral)	96h LC50>6.7 mg/L (rainbow trout) 96h LC50>2.25 mg/L (bluegill sunfish)
	Rovral Green	Rhone-Poulenc	20110	F	L	250 g/L	60-360 mL/10 L H_2O/100 m^2				
	Rovral 50W	Rhone-Poulenc	15213	F	P	50%	30-180 g/100 m^2				
mancozeb	Dithane M-45	Rohm & Haas	8556	F	P	80%	no turf use	range of fungal diseases	LD50>8000 mg/kg (rats, acute oral) LD50>10000 mg/kg (rats, acute percutaneous)	-	48h LC50>4.0 mg/L (carp)
	Dithane D.G.	Rohm & Haas	20535	F	P	75%	no turf use				
	Manzate 200 DF	DuPont	21057	F	P	75%	no turf use				
maneb	Manzate	DuPont	9082	F	P	80%	discontinued	range of fungal diseases	LD50>6750 mg/kg (rats, acute oral) LD50>5000 mg/kg (rats, acute percutaneous)	LC50>10000 mg/kg diet (mallard ducks & bobwhite quail, 8d dietary)	48h LC50 = 1.8 mg/L (carp)
MCPA	MCPA Amine 500	Agrevo Canada	21489	H	L	500 g/L	no turf use	broad-leaf weeds	LD50>700 mg/kg (rats, acute oral) LD50>1000 mg/kg (rats, acute percutaneous)	-	96h LC50>232 mg/L (rainbow trout)
mecoprop	Mecoprop	Green Cross	9191	H	L	150 g/L	55-85 mL/10L H_2O/100 m^2	broad-leaf weeds	LD50>930 mg/kg (rats, acute oral) LD50>900 mg/kg (rabbits, acute percutaneous)	-	low
	Dicot III	Scotts		H	G	0.61%	28.1/2044				
	Killex	Green Cross	8811	H	L	100 g/L	60 mL/5-10 L H_2O/100 m^2				
	Par III	United Agri Products	19810	H	L	100 g/L	30-60 mL/100 m^2 in suff. H_20				
	Trillion	Plant Products	18963	H	L	100 g/L	60 mL/100 m^2 in 10 L H_20				
	Tri-Kill	Sanex	19400	H	L	100 g/L	60 mL/100 m^2				
metalaxyl	Ridomil	Ciba-Geigy	17274	F	L	240 g/L	60 mL/13L H_2O/100 m^2	P	LD50>669 mg/kg (rats, acute oral) LD50>3100 mg/kg (rats, acute percutaneous)	~ non-toxic	96h LC50 = 1.8 mg/L (rainbow trout, bluegill sunfish, carp)
quintozene	FFII	Scotts	800278C	F	G	15.40%	15.9/1022	ds, rt, sm (F, sm, ls, bp, ds, r, ss)	LD50>12000 mg/kg (rats, acute oral, aqueous)	-	96h, 1.2 mg/L, no deaths (rainbow trout, golden orfe)
	Evergro	Scotts		F	G	15.40%					
	Plant Products	Plant Products	11425	F	P	75%	85-250 g/15-40L H_2O/100 m^2				
	Folosan	Uniroyal	11425	F	P	75%					
	Terraclor	Uniroyal	11425	F	P	75%	90-125 g/10-20L H_2O/100 m^2				

Pesticide			PCP Number	Biological Activity	Form	Fraction Active Ingredient	Recommended Application Rate	Target (literature)	Toxicity		
(active ingred.)	*(trade name)*	*(manufacturer)*					*(kg/m²)*		*(mammals)*	*(birds)*	*(fish)*
thiophanate-methyl	DSB Fungicide	Scotts	800264C	F	G	1.75%	17.7/2044 or 865 g/100 m²	ds, F, C DSB: (ds, F, bp, psm) Sys. F.: (ds, bp, cs)	LD50>7500 mg/kg (male rats, acute oral) LD50>6640 mg/kg (female rats, acute oral) LD50>2270 mg/kg (rabbits, acute oral) LD50>10000 mg/kg (rats, acute percutaneous)	LD50 > 5000 mg/kg (Japanese quail, acute oral)	48h LC50 = 11 mg/L (carp)
	Systemic Fungicide	Scotts	16660	F	G	2.30%	13.5/2044				
	Easout	Solaris Group	19465	F	P	70%	25-175 g/100 m²				
2,4-D	Dicot III	Scotts	841422C	H	G	1.22%	28.1/2044	broad-leaf weeds	LD50>375 mg/kg (rats, acute oral) LD50>1600 mg/kg (rabbits, acute percutaneous)	LD50>1000 mg/kg (wild ducks, acute oral) LD50>668 mg/kg (Jap. quail pigeons, acute oral) LD50>472 mg/kg (pheasants, acute oral)	toxicity dependant on formulation (ie. esters are more toxic than salts)
	Killex	Green Cross	8811	H	L	190 g/L	60 mL/5-10 L H_2O/100 m²				
	Par III	United Agri Products	19810	H	L	100 g/L	30-60 mL/100 m² in suff. H_2O				
	Trillion	Plant Products	18963	H	L	190 g/L	60 mL/100 m² in 10 L H_2O				
	Tri-Kill	Sanex	19400	H	L	190 g/L	60 mL/100 m²				

Legend:

Activity
F = fungicide
H = herbicide
I = insecticide

Form
G = granular
L = liquid
P = powder

Targets
anthr. = anthracnose
B = Botrytis
blw = broad leaf weeds
bp = brown patch
C = Corticium
cl = clover
cs = copper spot
ds = dollar spot
F = Fusarium
gr = grasses
gsm = grey snow mold
H = Helminthosporium
ls = leaf spot
M = Monilia
P = Peronosporales
Ph = Phytophtora
psm = pink snow mold
Py = Pythium
r = rust
rt = red thread
sm = snow mold
ss = stripe smut

Notes:

Toxicity information is provided for the active ingredient and not for the trade named product.

Sources:

Unless otherwise noted, target and toxicity information is from *Agrochemicals Handbook*, 1987.

( ) Denotes information from supplier.

3.0 SITE ASSESSMENTS

Site assessments were conducted at five courses in the study area: 3 Lower Mainland courses, 1 in the northern reaches of the Lower Fraser Region and 1 in the northern reaches of the Middle Fraser Region.

3.1 GENERAL ASSESSMENT PROCEDURE

The primary goal of the site assessments was to address the potential for surface water contamination as a result of golf course activities. Courses were examined with respect to:

- topography
- soils
- turf
- drainage
- irrigation practices
- maintenance area, housekeeping & miscellaneous
- chemical use & storage
- water quality monitoring

A limited sampling program was also conducted to try to characterize the quality of runoff from the courses. Ideally, to determine the contaminant contribution of runoff from a rainfall event, a comparison to background water quality is required. However, as background water quality can vary throughout the course of a year due to a number of factors such as chemical application rates, precipitation, temperature and turf health, it should be monitored on a continuous basis. Given the limitations of this project, this was not feasible.

Therefore, for this study, water quality characterization consisted of collecting one water sample at the time of the site assessment to serve as a background measurement and two water samples during or immediately after a significant rain event. Every effort was made to schedule the site assessments at a time when chemical application had not recently taken place and current and antecedent weather conditions were relatively dry. Every effort was also made to collect the rain event samples during or immediately following a significant rain event, after a minimum 72 hour dry period and after chemical application. It was not always possible to have these criteria coincide. Therefore, priority was given to sampling during a rain event following chemical application. In both cases, careful note was made of prior chemical applications, weather conditions and irrigation.

Any chemical applications prior to sampling consisted of primarily fertilizer use and negligible pesticide use, as pesticide requirements in B.C. during the summer season are limited (generally, only spot application is carried out). Sampling typically occurred following 10 mm of rainfall over 2 days -- during the period in which the Lower Mainland courses were to be assessed (April to June), there were only two daily rainfalls greater than 10 mm, unfortunately not coinciding with chemical application.

Sample locations at each course were selected based on their proximity to highly maintained areas (greens and tees), the location of underdrain outlets and the direction of surface runoff flow.

Water samples were obtained using either a Kemmerer or Van Dorn sampler. The number of grab samples taken to make a composite was dependant on the pond area, shape and depth; however, a minimum of three samples was always used.

Composite sediment samples were also collected at each course as part of the sampling program. These samples, obtained with an Eckman sampler, were collected from the same locations at which the water samples had been taken.

The pesticides for which tests were conducted were selected based on the chemical application history at each course.

3.2 SITE SELECTION

Site selection was based primarily on recommendations from Environment Canada. Factors which were taken into account included:

- proximity to a fish bearing stream;
- presence of waterbodies/watercourses on property;
- age of course;
- cooperation of superintendent;
- prior history of environmental concerns;
- climatic region; and
- location within the Fraser River Basin.

Sampling locations were selected based on the following criteria:

- amount of highly maintained area in the vicinity of the waterbody/watercourse (ie. greens and tees);
- size of the contributing drainage area;
- slope of the land surrounding the waterbody/watercourse; and
- presence of inlet structures.

3.3 SITE ASSESSMENTS

The names of the courses assessed and other names which may assist in the identification of the courses have been excluded from the following discussion. It is however recognized that it is difficult, if not impossible, to provide absolute anonymity to these courses, as each course has distinctive characteristics.

Site A - Lower Fraser, Lower Mainland Region

This course has been in operation for approximately 2 years and is situated in the floodplain of a fish bearing stream in the Lower Mainland. The site assessment took place April 5, 1995. At this time, sediment samples and a background water sample were also collected; the rain event samples were not collected until May 11, 1995. The layout of the site is depicted in Figure 3.1.

Topography

The topography of the course can be divided into three predominant zones: north (~45% of the total course area), middle (~10%) and south (~45%). Both the northern and southern zones are described as having a complex topography -- multiple slopes creating an irregular surface. The northern zone however consists of only gently undulating slopes in the range of 0.5 - 2%, while the southern zone consists of gently to strongly rolling slopes ranging from 5 - 30%. The middle zone is a single slope ranging from steeply sloping (30-60%) to moderately sloping (9-15%). (2)

Soils

The site also has three dominant soil zones: Westlang and Annis in the north, Milner and Berry to the south and Berry and Milner along the ridge between the north and south zones (2).

The Westlang soils at the north end are more predominant than the Annis. They are described as moderately fine to fine textured mixed marine and floodplain deposits. The Annis soils consist of approximately 15-40 cm of organic material over moderately fine textured floodplain deposits. Both types have characteristically poor drainage and are found in areas with a high groundwater table.

The Milner and Berry soils in the southern zone are respectively characterized as fine to moderately fine textured and moderately fine to fine textured marine deposits. While the former drains moderately well, the latter has imperfect drainage and is typically found above perched water tables. The middle zone also consists of Berry and Milner type soils, with Berry soils however in predominance.

The course was constructed on a 10-15 cm sand layer on top of the natural soils.

Turfgrass

The greens consist of one variety of bentgrass. The tees were seeded with a rye- and bentgrass mixture. However, the original 20-80 mixture is slowly developing into a 50-50 mixture as ryegrasses tend to dominate. Fescue, rye- and bentgrasses are found on the fairways.

Drainage

There are seven ponds on-site (1-6 & 4A), of which one is essentially an inlet from the adjacent river. The ponds may be considered lined because of the natural clays in the area. Average pond depth is approximately 3 m.

The ponds are all linked, with the exception of the Upper Pond (Pond 6). Like the other ponds, the Upper Pond is recharged from course runoff and with water from the stream adjacent to the course. However, unlike the other ponds, this pond can drain to the municipal stormwater collection system. The water levels in Ponds 1-5 & 4A can be controlled up to approximately 1.5 m. Any water beyond this level must be accepted by the ponds and by the course, if necessary (ie. flooding conditions, which have occurred in the past). In addition to stream water and course runoff, Pond 4 also accepts stormwater runoff from the maintenance area, the parking lot and from a 35 cm diameter pipe delivering stormwater runoff from off-site roads.

While the sand layer upon which the course is built aids in the infiltration of water, an extensive underdrain system throughout the course has also been constructed. On the greens, manual techniques (squeegees) are occasionally employed to reduce ponding.

The quality of drainage from the site is improved by leavestrips approximately 10 m wide along the riverbanks and the maintenance of grass at a height of 5 cm for a distance of approximately 6 m adjacent to the ponds. No pesticides are applied in these buffer areas.

Irrigation

Irrigation water is drawn from Ponds 1-6. In the summer months, approximately 2 - 2.5 cm of water per week are required for the greens, delivered in equal amounts over 7 nights. The longer grass on the fairways and tees requires less irrigation.

Maintenance Area, Housekeeping, Construction

Equipment is cleaned in the maintenance area with fresh water and no cleaning agents. Water is collected in a catch basin serviced by an inverted drain, discharging to Pond 4. Grass clippings/sludge have yet to be removed from the basin (the maintenance area was only recently constructed), but when build-up is sufficient a pumper truck will be used for clean-out.

Two fuel storage tanks (gasoline and diesel) are also kept in the maintenance area. There is no secondary containment nor drip pans for these tanks and the area around the tanks slopes to a catch basin approximately 1-2 m away.

The side slopes of some of the fairways are retained with creosote treated railway ties. Typically, these ties do not come into contact with pond water. Contact would only occur under flooding conditions.

Two holding tanks are available for the storage of domestic wastewater.

Chemical Use & Storage

Pesticides are stored in a specially constructed cupboard in the maintenance area. The bottom of the cupboard is fibreglass sealed and ventilation exists at the top. The doors of the cupboard will be properly secured when the cupboard has been completed. Fertilizer is kept in a locked room in the maintenance building. Chemicals are only ordered on an as required basis.

During the operating season, fertilizer is typically applied every 2-3 weeks on the greens, every 4-5 weeks on the tees, 3-4 times per year on the fairways and 2-3 times per year in the rough.

Pink snow mold is the most common problem for this course and typically requires quintozene application on the greens in November and again in January. To date pest problems have not been experienced in the summer. As a general rule, pesticides are only applied when problems become evident and other means of control have proven unsuccessful.

Water Quality Monitoring

Water quality monitoring is conducted by the course twice yearly to address both municipal, provincial and federal agency concerns. Sampling stations for water and aquatic invertebrates have been established on the river upstream and downstream of the outlet from Pond 1, in Ponds 2 and 6 and at the groundwater well by the pumphouse. Water samples are analyzed for physical characteristics and the concentrations of anions, cations, nutrients, metals and pesticides. The pesticides tested for are chlorothalonil, diazinon and iprodione. These three pesticides were selected as they were part of the course's original chemical management plan submitted to the municipality.

The results of the sampling conducted in September 1994 indicated that all of the stations exceeded the *Canadian Water Quality Guidelines* (3) with respect to either turbidity, colour, iron or manganese. However, the guidelines for these parameters are based on aesthetic objectives and the levels found do not pose any health risk (29). Three of the five stations also exceeded B.C. Environment's *Water Quality Criteria* (4) with respect to either suspended solids, dissolved aluminum or iron. The three pesticides were not detected in the water nor the invertebrate tissue samples.

Sampling

On the morning of April 5, 1995, composite sediment samples were collected from Ponds 2 and 6 and a composite background water sample was collected from Pond 6. The Environment Canada weather station, located within approximately 5 km of the course and at approximately the same elevation as the course, recorded the following weather conditions around the time of sampling: during the 24 hour period prior to sampling, 3.8 mm rain fell; during the night of April 4 and during the course of sampling on April 5, the weather conditions were dry. Pesticide use prior to this sampling event consisted of one quintozene application to the greens in January. Fertilizer had been applied more recently: a liquid fertilizer was applied to the greens approximately 10 days earlier and a granular fertilizer was applied to the greens in January.

The rain event samples were collected during the morning of May 11, 1995. According to data from the Environment Canada weather station, no precipitation fell on May 9, nor during the day of May 10. Between 5 p.m on May 10 and 9 a.m. May 11, 12.4 mm of rain were recorded. Fertilizer had been applied to the rough and the greens within the days immediately preceding sampling.

The sample locations are shown on Figure 3.1. The results of the water and sediment analyses appear in Tables 3.1 and 3.2.

TABLE 3.1
Chemical Analysis of Water Samples - Site A

Parameter	Units	Canadian Water Quality Guidelines [1]	B.C. Water Quality Criteria [2]	Background	Rain Event	
				Pond 6	Pond 6	Pond 2
Physical Tests						
conductivity	µmhos/cm	n/a	n/a	145	214	178
pH	-	6.5 - 9.0	6.5 - 9.0	7.69	7.27	7.49
suspended solids	mg/L	n/a	n/a	45	13	26
Organic Parameters						
BOD_5	mg/L	n/a	n/a	<5	<5	<5
COD	mg/L	n/a	n/a	46	40	<20
Nutrients						
ammonia-N [5]	mg/L-N	< 1.6	< 9.22	0.027	<0.005	0.031
total Kjeldahl-N	mg/L-N	n/a	n/a	0.93	1.01	0.66
total-N	mg/L-N	n/a	n/a	0.94	1.02	2.71
nitrite/nitrate-N	mg/L-N	n/a	n/a	0.008	0.008	2.05
nitrite-N	mg/L-N	0.06	0.06	-	-	-
nitrate-N	mg/L-N	n/a	200	-	-	-
dissolved ortho-P	mg/L-P	n/a	n/a	0.012	0.02	0.012
total-P	mg/L-P	n/a	0.005-0.015 [6]	0.141	0.16	0.108
Bacteriological Tests						
fecal coliform	MPN/100 mL	n/a	n/a [4]	80	60	80
Total Metals						
arsenic	mg/L	0.05	0.05	0.0007	0.0007	0.0008
cadmium [3]	mg/L	0.0002	0.0002	<0.0002	<0.0002	<0.0002
chromium	mg/L	0.002	0.002	0.002	<0.001	0.001
copper [3]	mg/L	0.002	0.0076	$\boxed{0.013}$	$\boxed{0.006}$	$\boxed{0.009}$
lead [3]	mg/L	0.001	0.043	0.001	<0.001	<0.001
zinc	mg/L	0.03	0.03	0.01	<0.005	0.005
Dissolved Metals						
arsenic	mg/L	n/a	n/a	0.0003	0.0003	0.0006
cadmium	mg/L	n/a	n/a	<0.0002	<0.0002	<0.0002
chromium	mg/L	n/a	n/a	<0.001	<0.001	<0.001
copper	mg/L	n/a	n/a	0.007	0.005	0.006
lead	mg/L	n/a	n/a	<0.001	<0.001	<0.001
zinc	mg/L	n/a	n/a	<0.005	<0.005	<0.005
Pesticides						
2,4-D	mg/L	0.004	n/a	-	$\boxed{0.0044}$	0.0017
dicamba	mg/L	0.01	n/a	-	0.0005	0.0002
mecoprop	mg/L	n/a	n/a	-	0.0025	0.0014
quintozene	mg/L	n/a	n/a	<0.0002	<0.0005	<0.0005

Notes:

☐	stipulated water quality guidelines or criteria exceeded
n/a	none available
<	less than the detection limit indicated
[1]	Canadian Water Quality Guidelines for Freshwater Aquatic Life, March 1995.
[2]	B.C. Environment Ambient Water Quality Criteria, Freshwater Aquatic Life, April 1995.
[3]	Cadmium, copper & lead limit based on a hardness of < 60 mg/L CaCO3.
[4]	Aquatic life limits are only for shellfish harvesting, no applicable limits for non- or secondary-contact waters.
[5]	Ammonia-N limit based on T = 17°C & pH = 7.7; as pH & T decrease, limit increases.
[6]	Total phosphorous limit applies only to lakes with salmonids as the predominant fish species; no limits proposed for streams.

TABLE 3.2
Chemical Analysis of Sediment Samples - Site A

Parameter	Units	B.C. Sediment Quality Criteria [1]	Pond 6	Pond 2
Physical Tests				
moisture	%	n/a	61.5	47.4
Particle Size				
gravel (>2.00 mm)	%	n/a	14.2	0.0
sand (2.00 mm - 0.063 mm)	%	n/a	20.8	56.3
silt (0.063 mm - 4 µm)	%	n/a	23.9	21.3
clay (< 4 µm)	%	n/a	41.2	22.4
Organic Parameters				
total C	%	n/a	2.4	1.3
Nutrients				
total-N	%	n/a	0.18	0.10
total-P	mg/dry kg	n/a	44	19
Total Metals				
arsenic	mg/dry kg	6	7.0	3.9
cadmium	mg/dry kg	0.6	0.2	0.2
chromium	mg/dry kg	26	37.0	31.2
copper	mg/dry kg	16	79.9	25.3
lead	mg/dry kg	31	9.1	5.5
zinc	mg/dry kg	120	158.0	91.0
Pesticides				
quintozene	mg/dry kg	n/a	<0.01	<0.01

Notes:

☐	stipulated sediment quality criteria exceeded
n/a	none available
<	less than the detection limit indicated
1	B.C. Environment Ambient Water Quality Criteria, Freshwater Sediment Quality, April 1995.

Site B - Lower Fraser, Lower Mainland Region

This course was constructed 25 years ago at the confluence of two fish bearing streams. Following the natural lay of the land, the course sits at two elevations. The assessment of the site took place on April 7, 1995. At this time, sediment samples and a background water sample were also collected. Rain event samples were not collected until June 7, 1995. The layout of the site is depicted in Figure 3.2.

Topography

The topography of the course falls into four basic zones, each roughly comprising 25% of the course area. In general, the topography is considered complex due to the multiple slopes. The northern portion of the course is steepest, consisting of moderately to strongly rolling slopes of between 9 and 30%. In the two sections towards the south, the slopes decrease from undulating 2 - 5% slopes to gently undulating 0.5 - 2% slopes. The section of the course furthest to the south increases again in slope, with grades in the range of 0.5 - 5%. (2)

Soils

To describe the soils, the course can be divided into the same four zones used to describe the topography. From north to south, the zones are comprised of the following soil types: i) Milner/Cloverdale, ii) Katzie/Banford, iii) Westlang and iv) Katzie. Both the Milner and Cloverdale soils are characterized as fine to moderately fine textured marine deposits. However, while the former drains moderately well, the latter has poor drainage and is typically found on perched water tables. The Katzie soils found in the second and fourth zones are described as fine to moderately fine textured, mixed floodplain deposits resulting in moderately poor to imperfect drainage. The groundwater level under this type of soil typically fluctuates. The Banford soils consist of approximately 40 - 60 cm of well decomposed organic material over medium and moderately fine textured floodplain deposits. Typically located on high groundwater tables, these soils have poor to very poor drainage. Finally, the Westlang soils found in the third zone are fine to moderately fine textured, mixed marine and floodplain deposits. Drainage in these soils, commonly located on high groundwater tables, is poor to very poor.

The course was built on approximately 25 cm of top soil. Only one green is constructed on a sand base.

Drainage

Due to the age of the course, detailed drawings of the drainage system are not available and no-one appears to have a complete knowledge of the system structure. A number of elements are however evident or known.

There are several ponds on the site and while they are not interconnected, they are all linked to a ditch which runs the length of the course. The ditch in turn discharges to the municipal stormwater collection system. Also connected to the ditch is perforated pipe which runs beneath the flat fairways, perpendicular to their length. The tees and greens do not contain any structures to assist with drainage.

As there is only one sand green on this course, water infiltration is generally poor and surface runoff is the principal mechanism of water removal from the course. The ponds are recharged through this surface runoff and precipitation. The ponds do not have synthetic liners, but are essentially lined because of the native clay material.

The course is protected from the flooding of one of the rivers by a dyke along the riverbank. The superintendent was not aware of any flooding as a result of water levels increasing in the second adjacent river.

A 10 m strip of unmaintained rough borders the undyked riverbank, helping to reduce any impacts on surface water quality. Grass around the ponds and the ditch is also kept at a greater length (~7.5 cm) than throughout the remainder of the course and is not chemically treated, again helping to protect surface water quality.

Irrigation

Water for irrigation purposes is drawn from the adjacent undyked river, at a maximum rate of 4 m^3/min.

Maintenance Area, Housekeeping and Misc.

Equipment is cleaned on a concrete pad in the maintenance area with fresh water and no cleaning agents. Wash water drains to the ground from the pad.

Fuel for the maintenance equipment is also stored in the maintenance area. A storm drain is located approximately 1 m downslope of the fuel drums. There is no secondary containment for the fuel and drip pans are not being used.

Domestic wastewater is treated in an on-site septic system.

Chemical Use and Storage

Chemicals (pesticides and fertilizers) are stored in a separate, locked room in the maintenance building. There do not appear to be any floor drains in the room. However, the floor does not appear to be sealed and there does not appear to be any means of secondary containment.

Chemical application is conducted roughly according to a supplier developed plan (Scotts): the superintendent applies his own judgement to the actual need for each recommended application. The plan calls for regular fertilizer use on the greens and tees throughout March to September. Fungicide use is called for on the greens in March, August, September, October, November and January and on the tees in October and December. The fairways are fertilized twice per year (April and August) and a fertilizer/fungicide/herbicide mixture is applied once per year (June).

Water Quality Monitoring

No environmental water quality monitoring is conducted. However, river water used for irrigation purposes is tested when problems with the condition of the turf arise.

Sampling

During the site assessment the morning of April 7, 1995, a composite sediment sample and a background water sample were collected from one pond and a second composite sediment sample was collected from the ditch. The Environment Canada weather station, located within 5 km of the course and at approximately the same elevation as the course, recorded no precipitation on the day prior to the assessment. Between 9 a.m. April 7 and 9 a.m. April 8, 4.2 mm precipitation fell. However, sampling was conducted during a dry period, after minimal rainfall, around 9:30 a.m. Prior to sampling, quintozene and thiophanate-methyl mixed with fertilizer had been applied to the greens in January and early March, respectively. Fertilizer had also been applied to the tees in mid-March.

The ideal rain event sampling conditions of a significant rainfall following a chemical application and a minimum 72 hour dry period were difficult to obtain. As a result, a decision was made to conduct the rain event sampling on the morning of June 7, 1995. During the 3 days preceding, 8.8 mm of rain had fallen and during the 2 days preceding, the greens and tees had been fertilized (the fairway pesticide application scheduled for June had been cancelled). Prior to this, the weather had been dry.

The sample locations are identified in Figure 3.2. The laboratory analyses are presented in Tables 3.3 & 3.4.

TABLE 3.3
Chemical Analysis of Water Samples - Site B

Parameter	Units	Canadian Water Quality Guidelines [1]	B.C. Water Quality Criteria [2]	Background	Rain Event	
				Pond	Pond	Ditch
Physical Tests						
conductivity	µmhos/cm	n/a	n/a	592	1150	205
pH	-	6.5 - 9.0	6.5 - 9.0	7.56	7.17	7.08
suspended solids	mg/L	n/a	n/a	67	31	41
Organic Parameters						
BOD$_5$	mg/L	n/a	n/a	11	18	8
COD	mg/L	n/a	n/a	102	145	151
Nutrients						
ammonia-N [5]	mg/L-N	< 1.6	< 9.22	<.005	<0.005	0.174
total Kjeldahl-N	mg/L-N	n/a	n/a	0.93	2.37	3.48
total-N	mg/L-N	n/a	n/a	0.94	2.38	3.50
nitrite/nitrate-N	mg/L-N	n/a	n/a	<.005	0.005	0.016
nitrite-N	mg/L-N	0.06	0.06	-	-	-
nitrate-N	mg/L-N	n/a	200	-	-	-
dissolved ortho-P	mg/L-P	n/a	n/a	0.022	0.002	0.027
total-P	mg/L-P	n/a	0.005-0.015 [6]	0.254	0.125	0.189
Bacteriological Tests						
fecal coliform	MPN/100 mL	n/a	n/a [4]	<2	1600	1600
Total Metals						
arsenic	mg/L	0.05	0.05	0.0023	0.0015	0.0069
cadmium [3]	mg/L	0.0002	0.0002	<0.0002	<0.0002	<0.0002
chromium	mg/L	0.002	0.002	$\boxed{0.003}$	$\boxed{0.003}$	<0.001
copper [3]	mg/L	0.002	0.0076	$\boxed{0.012}$	$\boxed{0.005}$	$\boxed{0.015}$
lead [3]	mg/L	0.001	0.043	$\boxed{0.002}$	<0.001	<0.001
zinc	mg/L	0.03	0.03	<.005	<0.005	0.007
Dissolved Metals						
arsenic	mg/L	n/a	n/a	0.0015	0.0005	0.0043
cadmium	mg/L	n/a	n/a	<.0002	<0.0002	<0.0002
chromium	mg/L	n/a	n/a	0.002	<0.001	<0.001
copper	mg/L	n/a	n/a	0.009	0.004	0.012
lead	mg/L	n/a	n/a	0.001	<0.001	<0.001
zinc	mg/L	n/a	n/a	<.005	<0.005	<0.005
Pesticides						
quintozene	mg/L	n/a	n/a	<0.0002	<0.00005	<0.00005
thiophanate-methyl	mg/L	n/a	n/a	<0.0002	<0.0025	<0.0025

Notes:

☐ stipulated water quality guidelines or criteria exceeded
n/a none available
< less than the detection limit indicated
[1] Canadian Water Quality Guidelines for Freshwater Aquatic Life, March 1995.
[2] B.C. Environment Ambient Water Quality Criteria, Freshwater Aquatic Life, April 1995.
[3] Cadmium, copper & lead limit based on a hardness of < 60 mg/L CaCO3.
[4] Aquatic life limits are only for shellfish harvesting, no applicable limits for non- or secondary-contact waters.
[5] Ammonia-N limit based on T = 17°C & pH = 7.7; as pH & T decrease, limit increases.
[6] Total phosphorous limit applies only to lakes with salmonids as the predominant fish species; no limits proposed for streams.

TABLE 3.4
Chemical Analysis of Sediment Samples - Site B

Parameter	Units	B.C. Sediment Quality Criteria [1]	Pond	Ditch
Physical Tests				
moisture	%	n/a	65.5	61.4
Particle Size				
gravel (>2.00 mm)	%	n/a	4.8	4.9
sand (2.00 mm - 0.063 mm)	%	n/a	2.1	12.7
silt (0.063 mm - 4 µm)	%	n/a	44.4	36.8
clay (< 4 µm)	%	n/a	48.7	45.6
Organic Parameters				
total C	%	n/a	7.1	7.1
Nutrients				
total-N	%	n/a	0.56	0.46
total-P	mg/dry kg	n/a	6.0	11.0
Total Metals				
arsenic	mg/dry kg	6	5.5	$\boxed{7.33}$
cadmium	mg/dry kg	0.6	0.4	0.4
chromium	mg/dry kg	26	$\boxed{56.7}$	$\boxed{63.5}$
copper	mg/dry kg	16	$\boxed{30.1}$	$\boxed{32.4}$
lead	mg/dry kg	31	10.7	13.4
zinc	mg/dry kg	120	87.5	90.6
Pesticides				
quintozene	mg/dry kg	n/a	<0.01	<0.01
thiophanate-methyl	mg/dry kg	n/a	<0.01	<0.01

Notes:

☐ stipulated sediment quality criteria exceeded

n/a none available

< less than the detection limit indicated

[1] B.C. Environment Ambient Water Quality Criteria, Freshwater Sediment Quality, April 1995.

Site C - Lower Fraser, Lower Mainland Region

Site C, situated adjacent to a river, is one of the oldest courses in the Lower Mainland. The course was assessed on April 28, 1995, during which time a background water sample and two sediment samples were also collected. Rain event sampling was conducted June 7, 1995. The layout of this course is shown in Figure 3.3.

Topography

Topographic mapping for this course was obtained from the municipality. This mapping showed that more than 90% of the area of this course undergoes less than a 3 m change in elevation and is thus virtually level. The remaining area, at the north end of the course, is situated on a relatively moderate to strong slope, ranging between approximately 6 and 10%.

Soils

Soil mapping was not available through either the municipality nor the B.C. Environment. However, it was evident through the inspection of the banks of the ditches and ponds (and confirmed by the superintendent), that the soils on-site consisted predominately of clays.

Drainage

While this course does have an underdrain system, it is somewhat haphazard in organization as it has been constructed over time as drainage problems have arisen. However, in general, the fairways, greens and tees have some form of underdrain collection, which discharges to the ponds or ditches on-site.

There are four natural ponds on-site and one concrete-lined pond. The natural ponds are essentially also lined due to the underlying clay material in the area. All five ponds are recharged by either precipitation, course runoff or city water. The ponds are drained in the winter to provide additional storage for the increased amounts of precipitation and runoff. Due to the shallow depth of the water table, a water level between 0.3 - 0.6 m is always present in the ponds, even after efforts to drain them. Two parallel ditches run through the southern half of the course, collecting and transporting drainage from the course, the ponds and the community upstream. These ditches in turn discharge to the adjacent river.

The greens and tees are constructed on a sand and sand/peat moss base to aid infiltration.

Surface water quality is protected through the use of 3 to 15 m leavestrips alongside the ditches and ponds. Turf may be cut up to the banks of the ponds, however, no fertilizers nor pesticides are applied adjacent to the ponds.

Irrigation

City water is used for course irrigation.

Maintenance Area, Housekeeping and Misc.

Maintenance equipment is washed in the maintenance area on a concrete pad. No detergents are used for cleaning. Wash water is collected in an inverted drain (which retains any grass clippings) and flows through an oil/water separator prior to discharge to the municipal stormwater collection system (ditch system).

Clippings from turf maintenance are collected for on-site composting.

Domestic wastewater is discharged to the municipal sewer system.

Chemical Use and Storage

Fertilizers and pesticides are stored in a locked and ventilated room in the maintenance building. The floor is constructed of concrete and there are no floor drains in the room. Chemicals are ordered on an as required basis. Only granular forms of pesticide are used.

During the operating season (April to September), the greens are fertilized approximately every 21 days, tees are fertilized once per month and fairways are fertilized 2 to 3 times per year.

Pink snow mold is the most commonly encountered problem at this course and may be combated with applications of quintozene or chloroneb during the months of October to December. During the foregoing winter season, four applications of quintozene to the greens were required.

Management Practices

While this course does not have its own documented Best Management Practice plan, significant effort has been made to follow the recommendations of the Audobon Society. This site has received certification from the Society in the categories of Environmental Planning and Wildlife and Habitat Management. Approximately 5 acres of the course has been set aside as a wildlife sanctuary. This area is entirely unmaintained (no mowing, no chemical use) and golfers are asked to refrain from entering this area. A natural pond and ditch shoreline is also promoted, providing aquatic and shoreline vegetative filters. The need for insecticides has been virtually eliminated, as the increased number of birds on-site have proven effective in controlling insect populations. Manual techniques are employed for the control of Veronica and Dandelions on the greens. However, elsewhere on the course where these weeds do not interfere with play, they are simply tolerated. Fountains and or water wheels have been established in some ponds to increase aeration and thus reduce chances of eutrophication.

Sampling

During the site assessment, a composite background water sample and two composite sediment samples were collected. The closest Environment Canada weather station, located at the airport less than 5 km from the course, confirmed that the weather on the 2 days prior to sampling and the day of sampling was dry. Chemical use prior to background and sediment sampling was limited. The fairways had not been fertilized since October of the preceding year. The last quintozene application had taken place in January 1995. The greens and tees had however been fertilized within the preceding week.

Again, ideal rain event sampling conditions were difficult to obtain and sampling was conducted on June 7, 1995 following three days of rainfall totalling 11.4 mm. The superintendent reported that sufficient rain had fallen the evening prior to sampling to eliminate the need for irrigation following that day's fertilizer application. However, the rainfall recorded at the Airport for that evening was negligible. There is thus reason to believe that the course may have received in excess of 11.4 mm of precipitation. The fertilizer application which occurred during the two days preceding sampling consisted of an application of 29-3-6 to the greens and tees and 35-3-7 to the fairways.

The sample locations are depicted in Figure 3.3. Analysis results are summarized in Tables 3.5 and 3.6.

TABLE 3.5
Chemical Analysis of Water Samples - Site C

Parameter	Units	Canadian Water Quality Guidelines [1]	B.C. Water Quality Criteria [2]	Background	Rain Event	
				Pond 1	Pond 1	Pond 2
Physical Tests						
conductivity	µmhos/cm	n/a	n/a	2120	533	23.7
pH	-	6.5 - 9.0	6.5 - 9.0	8.28	9.55	7.12
suspended solids	mg/L	n/a	n/a	31	35	5
Organic Parameters						
BOD_5	mg/L	n/a	n/a	19	11	<5
COD	mg/L	n/a	n/a	148	58	33
Nutrients						
ammonia-N [5]	mg/L-N	< 1.6	< 0.720	0.05	<0.005	<0.005
total Kjeldahl-N	mg/L-N	n/a	n/a	3.1	2.35	0.29
total-N	mg/L-N	n/a	n/a	3.11	2.35	0.29
nitrite/nitrate-N	mg/L-N	n/a	n/a	0.007	<0.005	<0.005
nitrite-N	mg/L-N	0.06	0.06	-	-	-
nitrate-N	mg/L-N	n/a	200	-	-	-
dissolved ortho-P	mg/L-P	n/a	n/a	0.661	0.752	0.009
total-P	mg/L-P	n/a	0.005-0.015 [6]	1.40	1.07	0.044
Bacteriological Tests						
fecal coliform	MPN/100 mL	n/a	n/a [4]	80	8	2
Total Metals						
arsenic	mg/L	0.05	0.05	0.0037	0.0031	0.0002
cadmium [3]	mg/L	0.0002	0.0002	<0.0002	<0.0002	<0.0002
chromium	mg/L	0.002	0.002	0.005	<0.001	<0.001
copper [3]	mg/L	0.002	0.0076	0.012	0.007	0.007
lead [3]	mg/L	0.001	0.043	0.001	0.001	<0.001
zinc	mg/L	0.03	0.03	<0.005	<0.005	<0.005
Dissolved Metals						
arsenic	mg/L	n/a	n/a	0.0028	0.0031	0.0002
cadmium	mg/L	n/a	n/a	<0.0002	<0.0002	<0.0002
chromium	mg/L	n/a	n/a	0.003	<0.001	<0.001
copper	mg/L	n/a	n/a	<0.001	0.005	0.005
lead	mg/L	n/a	n/a	<0.001	<0.001	<0.001
zinc	mg/L	n/a	n/a	<0.005	<0.005	<0.005
Pesticides						
chloroneb	mg/L	n/a	n/a	<0.0001	<0.002	<0.002
quintozene	mg/L	n/a	n/a	<0.0002	<0.00005	<0.00005

Notes:

☐ stipulated water quality guidelines or criteria exceeded

n/a none available

< less than the detection limit indicated

[1] Canadian Water Quality Guidelines for Freshwater Aquatic Life, March 1995.

[2] B.C. Environment Ambient Water Quality Criteria, Freshwater Aquatic Life, April 1995.

[3] Cadmium, copper & lead limit based on a hardness of < 60 mg/L CaCO3.

[4] Aquatic life limits are only for shellfish harvesting; no applicable limits for non- or secondary-contact waters.

[5] Ammonia-N limit based on T = 17°C & pH = 9; as pH & T decrease, limit increases.

[6] Total phosphorous limit applies only to lakes with salmonids as the predominant fish species; no limits proposed for streams.

TABLE 3.6
Chemical Analysis of Sediment Samples - Site C

Parameter	Units	B.C. Sediment Quality Criteria [1]	Pond 1	Pond 2
Physical Tests				
moisture	%	n/a	52.7	69.6
Particle Size				
gravel (>2.00 mm)	%	n/a	0.0	0.0
sand (2.00 mm - 0.063 mm)	%	n/a	69.8	16.1
silt (0.063 mm - 4 µm)	%	n/a	18.0	53.2
clay (< 4 µm)	%	n/a	12.2	30.7
Organic Parameters				
total C	%	n/a	1.9	3.2
Nutrients				
total-N	%	n/a	0.18	0.31
total-P	mg/dry kg	n/a	50	26
Total Metals				
arsenic	mg/dry kg	6	5.0	$\boxed{7.5}$
cadmium	mg/dry kg	0.6	0.2	0.5
chromium	mg/dry kg	26	$\boxed{32.5}$	$\boxed{61.9}$
copper	mg/dry kg	16	$\boxed{103}$	$\boxed{353}$
lead	mg/dry kg	31	5.7	18.2
zinc	mg/dry kg	120	67.9	$\boxed{171}$
Pesticides				
chloroneb	mg/dry kg	n/a	<0.002	<0.002
quintozene	mg/dry kg	n/a	<0.005	<0.005

Notes:

☐	stipulated sediment quality criteria exceeded
n/a	none available
<	less than the detection limit indicated
1	B.C. Environment Ambient Water Quality Criteria, Freshwater Sediment Quality, April 1995.

Site D - Lower Fraser, Northern Region

The fourth course to undergo assessment is situated in the floodplain of two parallel running rivers. Major construction of the course began in May 1993 and operation began in July 1994. The site assessment and background and sediment sampling took place on June 26, 1995; rain event sampling took place on July 11, 1995. The layout of this course is depicted in Figure 3.4.

Topography

The natural topography in this area falls between 0 and 2.5 %, nearly level. Any relief on the site was created during course construction and is considered minimal. (9)

Soils

Approximately two-thirds of the golf course consists of Valleau and Vickberg type soils, characterized as layers of medium to moderately fine textured soils interbedded with organic layers. The remaining one-third of the course, in the western portion, is characterized as predominately Sankey type soils. These soils are also described as medium to moderately fine textured, but without organic layers. All three types of soils are silty, fluvial deposits and are poorly drained. While both the Valleau and Sankey soils are typically found in areas with seasonally high groundwater tables, the Vickberg soils are found in areas of year round high groundwater (9). The adjacent sites, are dominated by more coarsely textured sandy fluvial deposits.

Turf

The fairways, greens and tees have been seeded with bentgrass. The maintained rough consists predominately of bluegrass with some rye. The large unmaintained areas consist primarily of fescues.

Drainage

As mentioned above, the on-site soils consist primarily of silty clays resulting in poor drainage conditions. Consequently, the site is interlaced with tile lines to improve the removal of water from the course and both the greens and tees are sand based (~35 cm). No direct discharge occurs to either of the rivers in proximity to the course, but rather to the on-site ponds.

Lying in the floodplain of two rivers and in a mountain valley, the course is susceptible to flooding. A berm has been constructed around the perimeter of the course in an attempt to attenuate potential damage from flooding conditions. Since course construction, no flooding of the area has occurred; the last major flood in the area was in 1984.

The on-site surface water system consists of ponds interconnected with ditches. Groundwater recharge and surface runoff provide an ongoing supply of water. The ponds are clay based and vary in depth to a maximum of approximately 4.5 to 6 m.

A 50 - 100 m buffer zone has been established between the course and the river bordering the property, helping to protect the river's water quality and allowing a corridor for wildlife movement. While maintenance of the turf apparently takes place up to the banks of the on-site waterbodies, the turf within approximately 3 m is maintained at a greater length than on the fairways, greens and tees.

Irrigation

The primary irrigation season extends from approximately mid May to the end of August. During drought conditions, the greens and tees may be irrigated 4 - 5 nights per week, the fairways 2 - 3 times per week.

Water for irrigation purposes is drawn from the on-site ponds. Currently, the irrigation of the entire course in one evening may require as much as 2400 m^3 of water. However, because the turf on this course is not yet fully established, the water requirements are temporarily considerably higher, approximately 25% higher, than those of a fully established course.

Currently, irrigation takes place once signs of turf stress are evident; soil probes are not used. Plans are in place to implement a weather station driven irrigation system which would take into account factors such as evapotranspiration, soil type, UV radiation and other agronomic criteria in establishing irrigation needs.

Maintenance Area, Housekeeping and Misc.

Maintenance vehicles are currently washed in the paved area of the maintenance yard, with drainage passing to the grassed perimeter. The construction of an inverted drain to collect the wash water and clippings has been planned. Soaps are not used in the wash process.

Grass clippings collected from the maintenance of the fairways, tees and greens are transported to local farmers for animal feed, with the exception of clippings generated after pesticide application.

Domestic wastewater is treated in an on-site rotating biological contactor.

Chemical Use and Storage

Conscious effort is made to apply the principles of integrated pest management to the maintenance of this site.

Fertilizer application takes place only after signs of nutrient deficiency become evident. In general, fertilization of the greens and tees is necessary every 2-3 weeks during May to September. Fairways are fertilized approximately 5 times per year.

Because the application of pesticides to bentgrass is undesirable, manual controls for broad-leaf weeds are used whenever possible. Daconil, Killex and Round-up may be required on a curative basis during the summer. The only biocide applied on a preventative basis is quintozene or iprodione prior to the winter (typically October/November) for protection against snow molds. If a snow blanket remains throughout the winter, no further quintozene applications to the fairways, greens or tees are required. No aquatic herbicides are used.

Chemicals are stored in a separate building specially fabricated for this purpose. Manufactured by ChemLock, the building has a grated floor with secondary containment means below. It is vented and may be heated when necessary.

Sampling

During the site assessment on June 26, 1995, the background water sample and sediment samples were collected. The Environment Canada weather station, located at the airport within 5 km of the course and at approximately the same elevation as the course, recorded no precipitation on the 3 days prior to the assessment. Fertilization of the front nine greens and tees had taken place the morning of this sampling. Prior to this, no fertilizer had been applied to the greens and tees in the preceding two weeks; to the fairways, since June 5; and to the rough, since June 9. For the most part, pesticide application had not taken place since the quintozene application in preparation for the winter -- it was later determined that chloroneb had been applied to two greens in March.

Rain event sampling was conducted July 11, 1995. The precipitation recorded at the Environment Canada weather station for the two days prior to sampling was 13.4 mm. Prior to these days the weather had been dry. The morning of the sampling, all 18 greens were fertilized.

The sample locations are shown on Figure 3.4. Analysis results are presented in Tables 3.7 and 3.8.

TABLE 3.7
Chemical Analysis of Water Samples - Site D

Parameter	Units	Canadian Water Quality Guidelines [1]	B.C. Water Quality Criteria [2]	Background	Rain Event	
				Ditch	Ditch	Pond
Physical Tests						
conductivity	µmhos/cm	n/a	n/a	110.5	116	126
pH	-	6.5 - 9.0	6.5 - 9.0	7.26	6.78	7.05
suspended solids	mg/L	n/a	n/a	9	11	3
Organic Parameters						
BOD_5	mg/L	n/a	n/a	50	<5	<5
COD	mg/L	n/a	n/a	1425	20	20
Nutrients						
ammonia-N [5]	mg/L-N	< 1.6	< 9.22	0.005	0.012	0.007
total Kjeldahl-N	mg/L-N	n/a	n/a	0.41	0.67	0.30
total-N	mg/L-N	n/a	n/a	0.41	0.68	0.30
nitrite/nitrate-N	mg/L-N	n/a	n/a	<0.005	0.008	0.005
nitrite-N	mg/L-N	0.06	0.06	-	-	-
nitrate-N	mg/L-N	n/a	200	-	-	-
dissolved ortho-P	mg/L-P	n/a	n/a	0.0165	0.016	0.004
total-P	mg/L-P	n/a	0.005-0.015 [6]	0.0435	0.055	0.023
Bacteriological Tests						
fecal coliform	MPN/100 mL	n/a	n/a [4]	90	110	130
Total Metals						
arsenic	mg/L	0.05	0.05	0.0001	0.0001	0.0001
cadmium [3]	mg/L	0.0002	0.0002	<0.0002	<0.0002	<0.0002
chromium	mg/L	0.002	0.002	<0.001	<0.001	<0.001
copper [3]	mg/L	0.002	0.0076	0.009	0.003	0.003
lead [3]	mg/L	0.001	0.043	<0.001	<0.001	0.001
zinc	mg/L	0.03	0.03	0.0445	0.028	<0.005
Dissolved Metals						
arsenic	mg/L	n/a	n/a	<0.0001	<0.0001	<0.0001
cadmium	mg/L	n/a	n/a	<0.0002	<0.0002	<0.0002
chromium	mg/L	n/a	n/a	<0.001	<0.001	<0.001
copper	mg/L	n/a	n/a	0.005	0.001	0.002
lead	mg/L	n/a	n/a	<0.001	<0.001	0.001
zinc	mg/L	n/a	n/a	0.021	0.013	<0.005
Pesiticides						
2,4-D	mg/L	0.004	n/a	<0.0001	<0.0002	<0.0003
chlorothalonil [7]	mg/L	0.00018	0.00018	-	<0.003	<0.003
dicamba	mg/L	0.01	n/a	<0.0001	<0.0002	<0.0003
iprodione	mg/L	n/a	n/a	-	0.013	<0.0001
mecoprop	mg/L	n/a	n/a	<0.0001	<0.0002	<0.0003
quintozene	mg/L	n/a	n/a	<0.0001	<0.0001	<0.0001

Notes:

☐	stipulated water quality guidelines or criteria exceeded
n/a	none available
<	less than the detection limit indicated
1	Canadian Water Quality Guidelines for Freshwater Aquatic Life, March 1995.
2	B.C. Environment Ambient Water Quality Criteria, Freshwater Aquatic Life, April 1995.
3	Cadmium, copper & lead limit based on a hardness of < 60 mg/L CaCO3.
4	Aquatic life limits are only for shellfish harvesting; no applicable limits for non- or secondary-contact waters.
5	Ammonia-N limit based on T = 17°C & pH = 7.7; as pH & T decrease, limit increases.
6	Total phosphorous limit applies only to lakes with salmonids as the predominant fish species; no limits proposed for streams.
7	Limits are stipulated for total concentration of chlorothalonil and its 4-hydroxy transformation product.

TABLE 3.8
Chemical Analysis of Sediment Samples - Site D

Parameter	Units	B.C. Sediment Quality Criteria [1]	Ditch	Pond
Physical Tests				
moisture	%	n/a	39.1	42.9
Particle Size				
gravel (>2.00 mm)	%	n/a	0.0	0.0
sand (2.00 mm - 0.063 mm)	%	n/a	15.0	22.6
silt (0.063 mm - 4 µm)	%	n/a	73.8	58.4
clay (< 4 µm)	%	n/a	11.2	19.0
Organic Parameters				
total C	%	n/a	0.7	1.6
Nutrients				
total-N	%	n/a	0.06	0.09
total-P	mg/dry kg	n/a	30	17
Total Metals				
arsenic	mg/dry kg	6	1.04	1.45
cadmium	mg/dry kg	0.6	<0.1	<0.1
chromium	mg/dry kg	26	9.6	12.9
copper	mg/dry kg	16	36.7	46.3
lead	mg/dry kg	31	3.1	4.1
zinc	mg/dry kg	120	113.0	62
Pesticides				
2,4-D	mg/dry kg	n/a	0.003	0.007
dicamba	mg/dry kg	n/a	0.002	0.002
mecoprop	mg/dry kg	n/a	<0.002	<0.002
quintozene	mg/dry kg	n/a	<0.005	<0.005

Notes:

☐ stipulated sediment quality criteria exceeded

n/a none available

< less than the detection limit indicated

[1] B.C. Environment Ambient Water Quality Criteria, Freshwater Sediment Quality, April 1995.

Site E - Middle Fraser, Northern Region

The first nine holes of this course, located within 3 km of the Fraser, were constructed almost 25 years ago; the second nine holes were added approximately 8 years ago. Due to the more northerly location of this course, the operating season falls between mid-April and mid-October. Assessment of the site took place August 28, 1995, at which time sediment and background water samples were also collected. Further sampling was conducted on September 28, 1995. The layout of this site is illustrated in Figure 3.5.

Topography

The majority of the course is comprised of variable slopes ranging between 2% to 9%, characterized as undulating to gently rolling. The slopes decrease in the northern portion of the course to 0% to 2%, nearly level to gently undulating. (10)

Soils

The golf course lies in an area considered part of the Pineview soil association. Over the expanse of the golf course varying percentages of orthic gray luvisol, gleyed gray luvisol and gleysolic soils are found. The upper layers of these soils are predominantly heavy clays, gradually changing to clays or silty clays with depth. In terms of drainage, this translates to moderately good to imperfect drainage throughout the majority of the course, with some pockets of poor drainage in the northern areas of the course (gleysolic soils). (10)

The tees and fairways were constructed on the native clays; the greens were constructed on a mixture of sand and soil.

Turfgrass

The greens, tees and fairways are comprised of a variety of grasses. Penncross bentgrass is found on the greens, bluegrass is found on the tees and the fairways consist of creeping red fescue, annual bluegrass and Kentucky bluegrass.

Drainage

Due to the native clay soils, the course was constructed with an underdrain collection system throughout the fairways, greens and tees. The drains discharge to either the ponds, creek or rough. In addition, the fairways are mounded to aid in the runoff of water. Flooding of the course has not been a problem.

There are three ponds on the course. The two smaller ponds, located in the vicinity of the creek which travels diagonally through the course, are connected to each other and the creek. Both have clay bottoms and are in the order of 1 - 1.5 m deep. The third pond, approximately 2 m deep, is connected via a culvert to the creek.

The primary means of recharging these ponds is through surface runoff, although water from the creek may also be pumped into the smaller ponds.

The creek is ephemeral, flowing through the course only during spring runoff (March - May). During the summer it is dammed approximately midway through the course to store water for irrigation purposes.

To reduce the impacts of drainage on surface water quality, fertilizer and pesticides are not applied within 3 meters of the creek and pond banks and the area adjacent to the creek are not mowed.

Irrigation

Water for irrigation purposes is drawn from the creek and from an on-site well. As water consumption is not metered, there are no records of the quantities of water used. Irrigation occurs when signs of stress appear.

Maintenance Area, Housekeeping and Miscellaneous

For the most part, compressed air is used to clean equipment, however on occasion water is also used. In the case of the latter, no detergents are added and the water drains to the ground around the paved maintenance area.

Clippings from turf maintenance are disposed of in the bush, while clippings cleaned off of maintenance equipment are disposed of in a dumpster.

Domestic wastewater from the course facilities is treated in an on-site lagoon.

Chemical Use and Storage

Pesticides are stored in a locked and ventilated room on-site. Fertilizers are stored under tarps in a shed.

Chemical use is guided by the experience of the on-site superintendents and Scotts representatives.
In general, fertilization of greens occurs every two weeks and the fertilization of tees and fairways occurs two to three times per year.

Common pest problems include thistle, dandelions, clover, dollar spot and snow molds. Dandelion and clover are adequately controlled with pesticide application every second year. More regular spot application of pesticides is required for thistles. For dollar spot, application of thiophanate-methyl is usually necessary. Preparation of the course for winter begins in October. This involves erecting snow fences on a number of exposed greens to help maintain protective snow covers and the preventative application of fungicides to combat snow molds.

Sampling

No water quality monitoring has been conducted in the past for this course.

During the site assessment, August 28, 1995, two composite sediment samples and a composite background water sample were collected. For the three days prior to the site assessment only a trace amount of rain (less than 1 mm) had been recorded at the Environment Canada weather station located within 10 km of the course. On the greens and fairways, no chemical applications had taken place within the two weeks prior to sampling: thiophanate-methyl had been applied to the greens two to three weeks previous and the fairways were last fertilized July 18. The tees and collars however were last fertilized 6 days previous with a fertilizer composition of 32 - 3- 10.

Rain event sampling took place September 28, 1995 following 7.8 mm of rain over two days. During the month of August, while precipitation was recorded 18 out of 31 days, the quantity of rainfall was generally less than 5 mm per day. Most importantly, there was apparently no significant use of fertilizers or pesticides during this month. While no pesticide application had occurred within the days prior to September 28, all 18 greens were fertilized with 4-4-12 on September 20. Weather conditions between the date of fertilization and the date of sampling were dry.

The locations at which samples were collected are identified in Figure 3.5. The results of the sample analysis are summarized in Tables 3.9 and 3.10.

TABLE 3.9
Chemical Analysis of Water Samples - Site E

Parameter	Units	Canadian Water Quality Guidelines [1]	B.C. Water Quality Criteria [2]	Background	Rain Event	
				Pond 1	Pond 1	Pond 2
Physical Tests						
conductivity	µmhos/cm	n/a	n/a	279	313	447
pH	-	6.5 - 9.0	6.5 - 9.0	8.37	8.46	8.52
suspended solids	mg/L	n/a	n/a	3	1	22
Organic Parameters						
BOD$_5$	mg/L	n/a	n/a	< 5	< 5	< 5
COD	mg/L	n/a	n/a	47	44	< 20
Nutrients						
ammonia-N [5]	mg/L-N	< 1.6	< 9.22	< 0.005	< 0.005	0.009
total Kjeldahl-N	mg/L-N	n/a	n/a	0.97	0.81	0.65
total-N	mg/L-N	n/a	n/a	0.97	0.82	0.65
nitrite/nitrate-N	mg/L-N	n/a	n/a	< 0.005	0.005	< 0.005
nitrite-N	mg/L-N	0.06	0.06	-	-	-
nitrate-N	mg/L-N	n/a	200	-	-	-
dissolved ortho-P	mg/L-P	n/a	n/a	0.002	0.001	0.001
total-P	mg/L-P	n/a	0.005-0.015 [6]	0.024	0.025	0.065
Bacteriological Tests						
fecal coliform	MPN/100 mL	n/a	n/a [4]	4	< 2	< 2
Total Metals						
arsenic	mg/L	0.05	0.05	0.0012	0.001	0.0005
cadmium [3]	mg/L	0.0002	0.0002	< 0.0002	< 0.0002	< 0.0002
chromium	mg/L	0.002	0.002	< 0.001	< 0.001	< 0.001
copper [3]	mg/L	0.002	0.0076	0.002	0.002	0.004
lead [3]	mg/L	0.001	0.043	< 0.001	0.004	< 0.001
zinc	mg/L	0.03	0.03	< 0.005	< 0.005	< 0.005
Dissolved Metals						
arsenic	mg/L	n/a	n/a	0.001	0.0009	0.0004
cadmium	mg/L	n/a	n/a	< 0.0002	< 0.0002	< 0.0002
chromium	mg/L	n/a	n/a	< 0.001	< 0.001	< 0.001
copper	mg/L	n/a	n/a	0.002	0.002	0.003
lead	mg/L	n/a	n/a	< 0.001	0.001	< 0.001
zinc	mg/L	n/a	n/a	< 0.005	< 0.005	< 0.005
Pesticides						
2,4-D	mg/L	0.004	n/a	< 0.00005	< 0.00005	< 0.00005
dicamba	mg/L	0.01	n/a	< 0.00005	< 0.00005	< 0.00005
mecoprop	mg/L	n/a	n/a	< 0.00005	< 0.00005	< 0.00005
thiophanate methyl	mg/L	n/a	n/a	< 0.0003	< 0.0005	< 0.0005

Notes:

☐	stipulated water quality guidelines or criteria exceeded
n/a	none available
<	less than the detection limit indicated
[1]	Canadian Water Quality Guidelines for Freshwater Aquatic Life, March 1995.
[2]	B.C. Environment Ambient Water Quality Criteria, Freshwater Aquatic Life, April 1995.
[3]	Cadmium, copper & lead limit based on a hardness of < 60 mg/L CaCO3.
[4]	Aquatic life limits are only for shellfish harvesting, no applicable limits for non- or secondary-contact waters.
[5]	Ammonia-N limit based on T = 17°C & pH = 7.7; as pH & T decrease, limit increases.
[6]	Total phosphorous limit applies only to lakes with salmonids as the predominant fish species; no limits proposed for streams.

TABLE 3.10
Chemical Analysis of Sediment Samples - Site E

Parameter	Units	B.C. Sediment Quality Criteria [1]	Pond 1	Pond 2
Physical Tests				
moisture	%	n/a	42.4	37.4
Particle Size				
gravel (>2.00 mm)	%	n/a	0.0	0.0
sand (2.00 mm - 0.063 mm)	%	n/a	4.9	8.6
silt (0.063 mm - 4 µm)	%	n/a	18.3	29.1
clay (< 4 µm)	%	n/a	76.8	62.3
Organic Parameters				
total C	%	n/a	0.39	0.25
Nutrients				
total-N	%	n/a	0.05	< 0.05
total-P	mg/dry kg	n/a	2.2	< 1.0
Total Metals				
arsenic	mg/dry kg	6	9.61	9.94
cadmium	mg/dry kg	0.6	< 0.1	< 0.1
chromium	mg/dry kg	26	22.7	22.3
copper	mg/dry kg	16	56	49
lead	mg/dry kg	31	10.1	9.3
zinc	mg/dry kg	120	477.0	304
Pesticides				
2,4-D	mg/dry kg	n/a	< 0.003	< 0.003
dicamba	mg/dry kg	n/a	< 0.002	< 0.002
mecoprop	mg/dry kg	n/a	< 0.002	< 0.002
thiophanate methyl	mg/dry kg	n/a	< 0.005	< 0.005

Notes:

☐	stipulated sediment quality criteria exceeded
n/a	none available
<	less than the detection limit indicated
[1]	B.C. Environment Ambient Water Quality Criteria, Freshwater Sediment Quality, April 1995.

3.4 SAMPLE ANALYSIS

3.4.1 Water Samples

The results of the surface water quality analyses were presented in Tables 3.1, 3.3, 3.5, 3.7 and 3.9. These results have been compared to the freshwater aquatic life *Canadian Water Quality Guidelines* (Guidelines) (3) and the B.C. Environment *Water Quality Criteria* (Criteria) (4). However, for the majority of the parameters tested no limits are stipulated in these documents.

General

Overall, a comparison of background data with rain event data did not indicate a marked decrease in surface water quality following chemical application and precipitation. Generally, conductivity increased in the rain event samples and on a few courses nutrient levels increased incrementally. On one course, where particular difficulties with large numbers of Canada Geese had been noted, there was a considerable increase in fecal coliform levels.

Three important limitations to these results should be mentioned. Firstly, the sampling program was limited. It was designed to provide only an indication of surface water quality at the courses and not a comprehensive study of factors affecting surface water quality. To determine the causes of any elevated parameters, further study is warranted. Secondly, significant rain events during the study period were limited. During the Lower Mainland study period (April to June), only 2 days recorded greater than 10 mm precipitation. Thirdly, chemical application on B.C. golf courses, during the April to September period when the site assessments took place, typically consist primarily of fertilizer application and very limited pesticide application (generally only spot treatment).

Metals

Comparison of the metals levels with the *Guidelines* and the *Criteria* indicated that copper levels were often exceeded, those for chromium, lead and zinc were less frequently exceeded and arsenic and cadmium limits were never exceeded. In the case of copper, the level of exceedance was in one case as high as a factor of seven. In most cases, the exceedance of the limits was less than two.

The cause of these elevated levels is difficult to conclude, as the sampling program was intended only to give an indication of surface water quality. Further study is necessary to isolate the actual causes. Potential contributing sources could be both natural and human. The main natural source of these metals is the parent material of the soils (7). Potential human sources of these metals could be numerous including fertilizers, pesticides, atmospheric deposition, piping and road run-off. For example, a fertilizer such as triple superphosphate (0-46-0) might contain as much as 92 ppm of chromium and 108 ppm of zinc and cow manure may contain 56 and 71 ppm, respectively, of these metals (7). Copper salts such as copper sulphate are often used to control algal blooms in ponds (8). While any fertilizer and pesticide contributions may be attributable to past and present golf course practices, it is also possible that upstream agricultural practices or past on-site agricultural practices could augment metals levels.

pH

The pH in the majority of the samples hovered around the neutral mark. In one case, however, the upper limit stipulated by the *Guidelines* and the *Criteria* was exceeded with a reading of 9.55. This high measurement occurred in a waterbody that already had an elevated pH during the background sampling (pH was 8.28) and was experiencing an algal bloom at the time of the rain event sampling. High pH and excessive algal growth can be associated with eutrophication, which may be caused by fertilizer runoff.

Organic Parameters

For BOD and COD, no limits are provided in the *Guidelines* or *Criteria* to offer comparison.

The sample BOD levels were generally below 20 mg/L. The COD levels ranged from less than 20 mg/L to 148 mg/L and an anomalously high 1425 mg/L. These results indicate that substantially more of the wastewater constituents may be chemically oxidized than biologically oxidized. Typically, for domestic wastewater, the ratio between COD to BOD is 3:1. In industrial wastes, where there is a greater likelihood that wastewater constituents are only chemically oxidizable, the ratio can be significantly higher.

Nutrients

Of the nutrient analyses, only the ammonia-N measurements could be compared directly to recommended limits. For all of the samples the ammonia-N levels were well below these limits.

The nitrite- plus nitrate-N measurements were compared to the nitrite-N limit (this limit is 0.06 mg/L, while the nitrate-N limit is 200 mg/L). With the exception of one sample, all combined measurements were below 0.06 mg/L. While the sample from Site A, with a reading of 2.05 mg/L, was significantly above the nitrite-N limit, it is possible that the additional nitrogen may be in the nitrate-N form.

With respect to total phosphorous, the *Criteria* stipulate a limit of 0.005-0.015 mg/L for lakes where salmonids are the predominant fish species; no limits are stipulated for streams. As it is unlikely that the ponds at which the sampling was conducted contained salmonids and the ponds discharged to either streams or stormwater collection systems, these limits are not directly applicable. However, it is noted that in all cases the samples exceeded the 0.015 mg/L upper limit, in one case by as much as a factor of almost 100. As some of these ponds discharge to watercourses, a comparison of their phosphorous levels to those for effluent quality stipulated in the *Draft Municipal Sewage Discharge Criteria* (ortho-P limit = 0.5 mg/L, total-P limit = 1 mg/L) (5) was made. The comparison showed that all but two samples from Site C were well below these limits. The two samples exceeding the limits did so by less than 0.25 mg/L ortho-P and 0.4 mg/L total-P.

Fecal Coliform

While fecal coliform limits for non- or secondary-contact waters were not available, there is a 200 MPN/100 mL limit for primary contact waters. All samples but two from Site B met this limit.

Those samples exceeding the limit were rain event samples, collected from a course where high numbers of Canada Geese had been noted.

Pesticides

In the majority of the samples, the pesticides which were tested for were not detectable. Exceptions were the measurements of 2,4-D, dicamba and mecoprop at Site A and iprodione at Site D. Of the pesticides detected, recommended limits were only available for 2,4-D and dicamba. The 0.004 mg/L limit for the former was exceeded marginally by a measurement of 0.0044 mg/L.

3.4.2 Sediment Samples

The results of the sediment sample analyses were presented in Tables 3.2, 3.4, 3.6, 3.8 and 3.10. For data comparison purposes, the sediment quality criteria in B.C. Environment's *Water Quality Criteria* (4) were consulted. Comparable criteria were however only available for metals.

Metals

Of the 6 metals tested for, four metals were found in concentrations exceeding the stipulated limits: arsenic, chromium, copper and zinc. All samples exceeded the copper limits, the majority exceeded the chromium limits and the arsenic and zinc limits were the least frequently exceeded. The copper limits were surpassed the most significantly, by a factor of as high as 22 in one sample collected at Site C.

The four heavy metals found in elevated concentrations were also found in elevated concentrations at golf courses studied by Okoniewski (1988). However, a literature review conducted in 1992 by Trutta Environments and Management for the Alberta Environmental Research Trust reported that no further information regarding high levels of heavy metals at golf courses (as a result of golf course practices) is available (6).

Based on the sampling program conducted, the sources of the elevated metals levels can not be isolated -- identification of the sources requires further study. As described for the water analyses, potential contributing sources may be both natural and human. They include soil parent material, fertilizers, pesticides, road run-off, piping and atmospheric deposition. The range of natural/background levels of heavy metals in soils can vary and must be taken into consideration when attempting to determine whether contamination is present and the extent of contamination. For example, a Canadian study has shown that background levels of zinc may be in excess of 100 mg/L; background levels of chromium may reach 100 mg/L; copper levels may be approximately 50 mg/L; and arsenic levels may be over 10 mg/L (7).

Organic Parameters and Nutrients

Total carbon measurements in the samples ranged from a low of 0.25% at Site E to a high of 7.1% at Site B. In general, total carbon levels averaged 2%.

With respect to nutrient levels in the pond sediment, total nitrogen varied between lows of less than 0.05% at Site E and highs of greater than 0.45% at Site B. Total phosphorous levels ranged from lows of less than 1.0 mg/dry kg at Site E to a high of 50 mg/dry kg at Site C.

Pesticides

Of the pesticides analyzed for, only two pesticides were detectable: 2,4-D and dicamba, both at Site D. No limits are stipulated for these pesticides in sediment or soils in either the B.C. Environment *Water Quality Criteria* (4) or the *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (9).

3.5 CONCLUSIONS

The superintendents of the golf courses visited were both aware of and interested in environmentally responsible golf course management practices. Elements of such practices were evident at each of the courses. However, as information regarding the environmental impacts of golf courses becomes more comprehensive and more rigorous management practices are developed, there will be room for improvement.

Of the parameters for which water and sediment quality criteria are available, total metals levels were the most frequently exceeded: the level stipulated for copper was surpassed in all samples; the limits for arsenic, chromium, lead and zinc were also surpassed, however less frequently. Pesticides were detected in 5 of the 25 water and sediment samples collected. With the exception of dicamba and 2,4-D, limits for pesticides in water or sediment were not available. One water sample exceeded the stipulated limit for 2,4-D, but only by 0.004 mg/L. The maximum concentration of a pesticide found was 0.013 mg/L of iprodione in a water sample.

There are a number of routes by which some of the sampled waters may find their way to surface waters. For example, through flooding, stormwater collection systems, pond water level adjustment or groundwater movement. However, as water quality criteria are generally stipulated for the most sensitive organisms, the metals levels found in the ponds may be toxic to organisms such as Daphnia magna, but not fish. To determine whether the exceedance of the limits is significant to fish requires investigation into the rationale behind the limits.

4.0 SUMMARY OF CONDITIONS & PRACTICES IN THE BASIN

Environmental factors such as climate and soil type significantly influence the decisions of turfgrass managers. These decisions pertain to grass selection, irrigation practices, drainage controls, pest management, fertilizer use and cultural intensity. An understanding of these conditions and current practices is essential for the development of effective Best Management Practices. A summary has thus been prepared based on the results of the golf course inventory and site assessments and general experience.

Three distinct environments can be identified within the Fraser Basin: i) the lower Fraser Valley, encompassing the area from Hope to the Fraser delta (essentially the Lower Fraser Region); ii) the dry south central interior as exemplified by the South Thompson River valley (essentially the Thompson Region) and; iii) the central interior area which stretches from Williams Lake to Prince George (essentially the Middle Fraser Region and to a limited extent the Upper Fraser Region). The ensuing discussion of conditions and current practices in the Fraser Basin has been sub-divided according to these three environments.

4.1 CLIMATE

Associated with the climatic differences between the regions are differences with respect to the requirements for irrigation and drainage. These have been presented below.

Lower Fraser Valley Region

The dominant climatic characteristic of the lower Fraser Valley is the high annual precipitation rate, generally exceeding 1 m. Despite this high rate, a water deficit exists through the months of July and August, because the precipitation is typically concentrated in the winter months. The Lower Fraser Valley is also the warmest region within the Fraser Basin (mean annual temperature of 9.8 °C at Vancouver). Thus, at lower elevations, the soils are frost free most of the year. Due to these climatic features, golf course superintendents face: i) long playing seasons, in the order of 9 to 10 months; ii) intense leaching during the periods of slow growth and heavy rain; and iii) a need for irrigation during the summer months.

Due to the heavy precipitation, there is a premium on having an excellent drainage system: most courses are continually updating or improving drainage each year. For upland courses, the emphasis is on the collection and movement of surface water through the use of drain lines which intercept runoff. The drain lines transport the runoff to ponds or ditches on the perimeter of the course or to dry wells where the water can percolate into the groundwater system. On lowland courses proper drainage also necessitates management of the water table.

Although the period through which irrigation is required is short and the water deficit is low (approximately 100 mm), it coincides with the period of most intense play, increasing irrigation demands. While new irrigation systems are quite sophisticated in the distribution and control of irrigation water, many of the older courses are using less efficient systems. Upgrading irrigation systems is generally difficult because of the perception that irrigation is not essential to the maintenance of high quality turf. This perception is based on the high annual precipitation rate in the region. In reality however, the evaporative demand of turf is much higher than the ability of the soil or rainfall to supply water and most superintendents need to hand water greens during periods of hot weather to protect the turf from drought stress.

South Thompson River Valley Region

The climatic conditions of the South Thompson River Valley region contrast greatly with those of coastal B.C.'s. The dominant feature of this region's climate is the low annual precipitation, as low as 350 mm per year. Precipitation tends to be concentrated in the late fall or early winter and spring. Generally, evaporation exceeds precipitation from May through to September. The combination of high day time temperatures, 25°C to 30°C, and valley winds contribute to high turfgrass evapotranspiration rates. The growing season ranges between 6 and 7 months, depending on location and year. The ground is frozen approximately 3 months of the year. During the winters, snow cover in the lower areas is minimal and extensive winter kill of turf occurs as a result of desiccation.

Due to the climatic conditions, irrigation is a primary management concern: moisture deficits through the summer can be as high as 400 mm. New golf courses generally have high quality irrigation systems which cover the whole course. Justifying the need to retrofit old courses with improved irrigation systems is less difficult in this region. However, many member owned courses lack the financial resources to be able to upgrade a system in a timely manner. Due to high irrigation requirements, the use of treated sewage is often a practical consideration at courses. However, some courses which have been using this approach for a number of years have reported problems with iron chlorosis (iron deficiency in plants).

Surface drainage is a standard feature of many courses in the region. The use of dry wells as water collection areas is much more prevalent than in the Lower Fraser Valley region.

Prince George Region

The climate in the northern portion of the Fraser Basin, the Prince George region, is characterized by low mean annual temperatures (3°C), moderate rainfall (600 mm) and high accumulations of snowfall. The period of water deficit extends from June to August and in total is approximately 100 mm. The growing season is short, 5 months, and the winters are severe. Cold temperature stress and the prevention of winter damage is a significant problem.

4.2 SOILS

The Fraser River Basin encompasses the Coast Mountains, the Interior Plateau and the Rocky Mountains. That general topography is the result of plate tectonics, but the dominant factor affecting the land forms and surficial deposits within the Basin is glaciation. The last glacial period, the Fraser glaciation, reached its maximum extent 15,000 years ago. By 9,500 years ago, the ice had retreated to its full extent. The oldest soils within the Basin are therefore approximately of this age.

The general characteristics of the soils within each region are a good measure of the combined effects of topography, parent material, vegetation and climate. The latter was addressed in the previous section; the former are addressed below.

Lower Fraser Valley Region

Within the region the topography ranges from deltaic plains to rolling upland areas which are sloped severely enough to affect the agricultural capability of the land. Courses which have been built along the valley walls have had to deal with significant elevation changes.

The parent materials in the Lower Fraser Valley region are dominated by post-glacial deposits. Alluvial silts, sands and gravels can be found throughout the region. Marine clays underlie most of these deposits. Extensive glacio-marine parent materials cover upland areas within the region. Where marine deposits are close to the surface, drainage is a significant problem. Construction on soils where marine clays dominate can be difficult and the use of clay soils to construct the subgrades for greens and tees can create irrigation management problems for the superintendent.

Upland, well drained soils which formed on medium to coarse parent materials are dominated by Humo-Ferric Podzols. These Podzolic soils are intensely leached, very acidic and generally infertile. The A horizon is leached of iron, aluminum and organic matter. All three accumulate in the B horizons. Cultivation of these soils therefore generally involves cultivation of the B horizon. For turfgrass production, the soils generally require lime, magnesium, potassium and sulphur addition. While native soils also have extremely low phosphorous levels, the demand for additional phosphorous is reduced on courses built on converted agricultural land due to past phosphorus fertilization.

The more poorly drained areas in the floodplains and deltas are dominated by Humic Gleysols. Associated with the Gleysols are also the Eutric Brunisols, Grey Luvisols and organic soils. The parent materials are usually fine textured, which exacerbates existing drainage problems. Gleysols generally have an organic rich A horizon and with good drainage can be very fertile. Again lime, phosphorous, potassium and magnesium will generally be limiting.

Plant communities within the Lower Fraser Valley generally fall within the Coastal Douglas Fir biogeoclimatic zone. Because a significant number of golf courses have been constructed on what was previously farmland, the effects of the native vegetation have been somewhat modified by the past agricultural production.

South Thompson River Valley Region

The topography in the South Thompson River Valley Region tends to be rolling or gently hilly.

The parent materials in the upland areas are often glacial till. A range of alluvial deposits can be found along the rivers. Glacio-lacustrine silt deposits dominate the valley walls. In most areas the upper 20 - 30 cm of soil is affected by the addition of aeolian deposits of very fine sands. The glacio-lacustrine deposits are often deeply eroded, creating gullies through the deposits. Slumping is a concern with the development of these areas, particularly if septic tanks are used for sewage treatment or if farmland, home lawns or golf turf is excessively irrigated.

The dominant soils of the area are considered to be grassland soils. In the warmer sections, at lower elevations, soils tend to be Brown or Dark Brown Chernozems. Since most golf courses within the region are near towns which were generally established along the rivers, most courses are constructed on these soils. At higher elevations, Eutric Brunisols can be found in the drier areas and Grey Brown Luvisols in the moister areas.

The soils within the region are generally fertile, well drained and relatively easy to manage. The low rainfall has resulted in minimal leaching and free lime can typically be found at depths between 30 and 60 cm. Native soil pH levels tend to be neutral, although nitrogen fertilization and irrigation can cause soil pH to drop, so that over time lime addition may be required. This effect is more common to areas of intense agricultural production. Low micronutrient levels pose a concern on occasion: soil boron and zinc levels tend to be low and iron can become unavailable when soil pH is high.

The native vegetation in the area is predominated by Ponderosa Pine and bunch grass.

Prince George Region

The parent materials of the soils found in the Prince George region are dominated by glacial tills and to a lesser extent, glacio-lacustrine deposits. The resulting soils tend to be medium to fine textured. Again, alluvial deposits are found along the rivers or in areas where glacial meltwaters once flowed.

The dominant soil forming process in this region is clay leaching. Clay and organic matter tend to be leached from the fine textured soils found in the drier areas, creating Grey Luvisolic soils. The A horizons are low in organic matter and are dominated by silts or fine sands. Due to the accumulation of clay in the B horizon, the Luvisolic soils have poor internal drainage. Compaction of wet soils can be a serious concern.

The soils tend to have neutral to slightly acidic soil pH's and have relatively high base saturations. Nitrogen and phosphorus are typically lacking. Overall, agriculture has had a smaller influence on the soil properties of land used for golf courses.

The dominant vegetation types are Cariboo Aspen Lodgepole Pine communities in the southern portion of the region and Sub Boreal Spruce communities in the northern portion of the region.

4.3 PRIMARY CULTURE

The purpose of this section is to identify the turf selection, pest management and fertilizer use practices unique to each region.

In the Fraser River Basin, insect problems are relatively uncommon. A number of diseases are however quite prevalent: snow molds, brown patch, leaf spot and red thread. Weeds common to the Basin are listed in Table 4.1.

Table 4.1
Weeds Common to Golf Courses in the Fraser River Basin

Common Name	Scientific Name	Common Name	Scientific Name
Dandelion	Taraxicum officinale	Creeping Charley	Glechoma herdracea
Spotted Cats-Ear	Hypochoeris radicata	Prostrate Knotweed	Polygonum aviculare
Broad Leaf Plantain	Plantago major and Plantago rugelli	Shepards Purse	Capsella bursa-pastoris
Narrow Leaf Plantain	Plantago lanceolata	Red or Sheep Sorrel	Rumex acetosella
White Clover	Trifolium repens	Veronica	Veronica fillformis
Low Hop Clover	Trifolium procumbens	Healall	Prunella vulgaris
Common Chickweed	Stellaria media	Pearlwort	Sagina procumbens
Mouse-Eared Chickweed	Cerastium vulgatum	Yarrow	Achillea millefollum
Creeping Buttercup	Ranunculus repens	Smooth Crabgrass	Digitaria ischaemum
English Daisy	Bellis perennis	Velvet Grass	Holcus lanatus

Fertilizer programs, for all components except nitrogen, are generally based on the results of soil tests. Nitrogen rates are usually determined by the superintendent in response to the amount of play, the recuperative rate of the grass, the desired growth rate and the desired visual quality. There has been an increasing trend towards foliar analysis and the tracking of turf nutrient content throughout the year to determine fertilization scheduling. However, this is not yet a common practice. A summary of typical nitrogen application practices for courses in the Fraser River Basin is provided in Table 4.2.

Table 4.2
Summary of Nitrogen Application Practices in the Fraser River Basin

Region	Turf Area	Annual Nitrogen Rate (kg N/100 m^2)	Applications/Year*
Lower Fraser Valley	Greens	2.5 - 4	6 - 8
	Tees	2.5 - 4	6 - 8
	Fairways	1.5 - 2	3 - 4
	Rough	1.5 - 2	3 - 4
South Thompson	Greens	1.75 - 2.5	4 -6
	Tees	1.75 - 2.5	4 -6
	Fairways	1.5 - 2	3 - 4
	Rough	1.0 - 1.5	2 - 4
Prince George	Greens	1.5 - 2	3 - 5
	Tees	1.5 - 2	3 - 5
	Fairways	1 - 1.5	2 - 3
	Rough	0.75 - 1.25	2 - 3

* Using granular materials.

Lower Fraser Valley Region

Turfgrass

Creeping bentgrass (*Agrostis stolonifera*) is the species most selected for greens within the region, primarily for its ability to withstand the low mowing required. The mowing height is generally around 0.5 cm and may be lower on some courses where increased green speed is desired. Greater use of colonial bentgrass *(Agrostis tenuis*) on tees and fairways is occurring as more improved varieties become available.

Tees, fairways and roughs within the region are primarily planted to perennial ryegrass. This species only requires a medium level of management to maintain good quality. The most serious drawback to the use of perennial ryegrass is its bunching growth habit. It is also slow to spread into damaged areas and requires periodic overseeding.

Fine leaf fescues are being used more frequently in mixes designed for roughs. The primary impetus behind the selection of fescues (such as hard fescue) is a reduction in maintenance requirements: they require less fertilizer, less water and are slower growing.

Kentucky bluegrass is not well adapted to the Lower Fraser Valley and as such represents a minor component of most mixes.

Annual bluegrass, because of its competitive ability in the Lower Fraser Valley, is the most prevalent grass. Its drawbacks are that it is a prolific seed producer and seed production results in lower quality turf in the spring. From a practical standpoint, the acceptance and management of annual bluegrass is preferred to its control: cultural control (ie. core cultivation to control soil compaction; reducing the amount of nitrogen applied and avoiding early spring nitrogen application; using lightweight mowing equipment on the fairways and removing the clippings; maintaining turf canopy heights of 0.5 cm) of annual bluegrass is difficult and no chemical controls are registered. Unfortunately, for aesthetic reasons, superintendents are often required to control annual bluegrass.

Pest Management

Insects

European cranefly is the dominant insect pest in the Lower Fraser Valley. Outbreaks generally encompass small areas rather than widespread, regional areas. Populations of larvae between 10 and 20 per 0.1 m^2 can be considered damaging, depending upon the vigour of the turf. If necessary, pesticides such as diazinon are applied in early April, although late October applications have also been used.

Weeds

Weed control is the most intensive on greens and tees. Where single plants are found, hand weeding rather than herbicide application is often used. Weed control on fairways is achieved largely with herbicide application. Spot treatment of fairways may be used for localized outbreaks. Rough areas are the least intensively managed: herbicides are infrequently used.

Most of the common perennial broadleaf weeds are controlled with the use of a 2,4-D, mecoprop and dicamba herbicide combination. Where broadleaf weed control in bentgrass is required, formulations without 2,4-D are used. In areas where leaching is a concern or in areas near ornamental plantings, the use of dicamba is reduced due to the leaching potential of the herbicide. The preferred time of application is in the early fall, although spring applications can also be effective.

Diseases

Disease represents the largest pest pressure in the Lower Fraser Valley region. For established turf this pressure occurs primarily from mid fall to mid spring. Diseases common to this period include red thread, pink snow mold, cool season brown patch and leaf spot diseases. Anthracnose is a common hot weather disease for certain grasses and new golf courses can also face problems with take-all patch and Pythium.

Control of disease outbreaks is usually achieved with applications of fungicides. Common contact fungicides include anilazine, chloroneb (some systemic activity), chlorothalonil, iprodione (some systemic activity) and quintozene. Systemic fungicides include benomyl, carbathin, propiconazole and thiophanate-methyl. A standard practise is to alternate the use of appropriate contact and

systemic fungicides as a method of preventing the development of fungicide tolerant strains of the turfgrass diseases.
Cultural methods employed in the control of disease include improving soil drainage, air flow and soil fertility. Reducing the amount of shade around turf areas and minimizing the period over which the turf is wet can also be of assistance. The control of thatch is also a good general cultural control for minimizing the impact of diseases.

Red thread (*Laetisaria fuciformis*) is usually not treated with fungicides. Outbreaks are common in the spring during wet weather and on turf which is growing slowly. Increasing the vigour of the turf by increased nitrogen fertilization will often result in an adequate level of control. Removing turfgrass clippings from infected areas helps to slow the spread of the disease.

Pink snow mold (*Michrodochium nivale*) is one of the more serious cool season diseases. Many superintendents will use combinations of contact and systemic fungicides to control the disease. Applications are usually made prior to predicted snow falls.

Cool season brown patch is a disease which occurs on highly fertilized, thatchy sites during periods of wet weather. It can be controlled by a wide range of fungicides.

Leaf spot diseases are controlled by fungicides such as iprodione and chlorothalonil.

Anthracnose (*Colletotrichum graminicola*) is a hot weather disease of bentgrass and annual bluegrass. It is most frequent after periods of wet warm weather and on greens that are poorly fertilized and have soil compaction. Propiconazole can be used to control anthracnose, but cultural control by reducing other environmental stresses is important.

On new golf courses two other diseases are common, take-all patch (*Gaeumannomyces graminis var. avenae*) and Pythium root diseases (*Pythium spp*). No chemical control is registered for Pythium and this disease can devastate new greens. Cultural control for take-all patch involves the use of sulphur or ammonium sulphate to reduce soil pH levels.

Fertilization

One of the major challenges facing the superintendent is the management of growth at the beginning and end of the growing seasons. Turfgrasses, especially perennial ryegrass, tend to thin over the winter and are not particularly strong in the early spring. Unfortunately, there is often pressure to open courses early, before significant growth has occurred.

Typical nitrogen application rates and frequencies for the Lower Fraser Valley region were listed in Table 4.2. Some superintendents may however be fertilizing greens more frequently, at very low rates, through the use of fertilizer solutions. In general, fertilization rates are not distributed uniformly over the growing season. Peaks in application rates occur in mid to late spring and in late summer. Often, particularly during the summer, superintendents will match potassium application rates with nitrogen rates on sand greens and tees. The maintenance of a nitrogen/potassium balance increases the stress tolerance of turf.

Fertilization rates on new plantings can be significantly greater, in some cases as high as 7 kg/100 m^2/year on greens. Although there is great potential for leaching during the turf establishment phase, a tradeoff has been made by attempting to minimize the time to full establishment through increased fertilizer use.

A great variety of products are available for the supply of nitrogen. The types most predominately used in the Lower Fraser Valley are soluble sources (urea and ammonium sulphate), coated ureas (sulphur and resin), synthetic organics (IBDU and ureaformaldehyde) and natural organics. IBDU is a good source of nitrogen during the cooler moister periods of the year, because of its release mechanism. The greatest drawback to the use of IBDU is its relatively high cost. The use of coated products is very common and the new coating technologies offer greater dependability in the nitrogen release rate. Most fertilizer companies are now selling high quality fertilizer blends which contain a variety of nitrogen sources.

South Thompson River Valley Region

Turfgrass

With respect to turfgrass selection, the most significant difference between the Lower Fraser Valley region and the South Thompson River Valley region is the increased predominance of Kentucky bluegrass. Kentucky bluegrass is well adapted to the region and replaces perennial ryegrass as the dominant grass on fairways and rough.

In rough areas, hard and sheep fescues are being used more frequently. Superintendents are also selecting crested wheatgrass and fairway wheatgrass in rough areas which are not part of play.

Pest Management

Insects

Insect problems are not common at golf courses in the South Thompson River Valley region.

Diseases

Although brown patch and leaf spot diseases are similarly controlled in the South Thompson region, they are less common than in the Lower Fraser Valley. Red thread and Pythium are also less commonly reported due to the more arid climate. Snow molds, in particular gray snow mold, are a serious problem in the South Thompson region and in some areas during the summer, dollar spot is also a concern.

Differences exist in the control of snow molds in the South Thompson region, particularly with respect to cultural controls. Because of the seriousness of gray snow mold problems, preventative treatment of greens and tees is often required. Also, covers are more frequently used for the protection of greens and fences are used to control the accumulation of snow. Fairways are generally not treated due to the cost.

Dollar spot is treatable with most fungicides, with the exception of chloroneb. An approach used to lessen the impact of dollar spot is the slight increase of nitrogen applications.

Weeds

Weed problems and treatment methods in the South Thompson region are comparable to the Lower Fraser Valley region. Exceptions are the existence of Russian and spotted knapweed in areas along fence lines and parking lots and in unirrigated rough and the less common occurrence of spotted cats-ear.

Fertilization

In general, the approach to fertilization is similar to the Lower Fraser Valley region. However, the shorter growing season in the South Thompson region reduces the need for nitrogen (see Table 4.2). Because of the distinct period of time during which the ground is frozen, late fall nitrogen fertilization is effectively used.

Iron levels may be deficient where soils have high pH values or where treated sewage effluent has been used for irrigation (iron chlorosis). This is often mitigated with foliar applications of ferrous sulphate or ferric chelates. Application of iron for uptake by grass roots is not as effective.

Prince George Region

Turfgrass

Kentucky bluegrass and fine fescues are the dominant grasses for fairway and rough areas. Perennial ryegrass is a component of most seed mixes, but generally does not comprise more than 20% of the mix. It is not well adapted for the climatic conditions of this region and therefore behaves more like a short lived perennial in this area.

Creeping bentgrass is used for greens and occasionally tees. Creeping bentgrass is one of the most cold tolerant grasses, so its use on tees depends more on management levels than climate.

Pest Management

Insects

Insect concerns on golf courses in the Prince George region are not common.

Weeds

The weeds encountered in the Prince George region and the control methods employed are similar to those of the South Thompson region (with the exception of smooth crabgrass which may not be prevalent). Any management differences are due to the shorter growing season, which compresses operations into 4 to 5 months.

Diseases

Coprinus snow mold and Low Temperature Basidiomycete snow mold are particular problems in the Prince George region. Again, the snow mold group of fungi are the only diseases for which there is a regular preventative treatment program.

Fertilization

The lower rates of fertilization in the Prince George region, as shown in Table 4.2, are a reflection of the region's shorter growing season. IBDU, coated and soluble fertilizer products are commonly used in the region. However, due to the short period of warm soils, nitrogen fertilizers which depend upon microbial mineralization, such as ureaformaldehydes and organic sources, are less effective nutrient sources.

5.0 BEST MANAGEMENT PRACTICES REVIEW

To identify existing golf course Best Management Practice documents and/or initiatives towards the development of Best Management Practices, a search of select electronic databases was made and government representatives and golf associations were interviewed. It was evident that while Integrated Pest Management (IPM) plans are prevalent at U.S. golf courses (their existence is limited in Canada), Best Management Practice documents are not as common. Some may argue that the difference between the two is a matter of semantics. However, in general, while integrated pest management plans are comprehensive management documents and integral to a BMP plan, BMP plans are considered to address a broader range of environmental impacts and concerns.

5.1 DATABASE INFORMATION

The *Turf Grass Information File* (TGIF) at Michigan State University is an excellent database on topics relating specifically to golf course management. A subscription to this source is US$75 per year. Mr. Pete Cookingham, Project Manger for this initiative, may be contacted for further information.

A search for documents pertaining to golf course management was conducted through the NTIS database (for U.S. government publications) and the Water Resources and Environmental Abstracts databases (for commercial publications). With the exception of one EPA document, *Integrated Pest Management for Turfgrass and Ornamentals*, this search did not reveal any existing IPM or Best Management Practice (BMP) plans or planning guides. However, innumerable articles were found on issues relating to the environmental impacts of golf courses. These articles have been categorized in Table 5.1 into chemical use, water quality, stormwater management and other environmental issues. Further articles on these topics can also be found in a journal entitled *Golf Course Management* (this journal was not included in the databases searched). A review of the EPA integrated pest management document is provided below.

Integrated Pest Management for Turfgrass and Ornamentals, 1989

This EPA document is the product of a symposium held at the 1987 American Chemical Society meeting. Topics addressed included the problems associated with the chemical control of pests, benefits of the Integrated Pest Management (IPM) approach, research regarding pests and chemical application sites, research on the biological control of pests, current pest control practices and IPM development. Of particular interest to this study were the papers on surface runoff and IPM development.

Table 5.1
Relevant Articles found through Database Search
(NTIS, Water Resources Abstracts, Environmental Abstracts)

TITLE	Integrated Pest Management	Chemical Use	Water Quality (surface)	Water Quality (groundwater)	Stormwater Management/ Stormwater Runoff	Golf Course Planning/Construction	Other Environmental Impacts (ie. fish, wildlife, wetlands, etc.)
Survey of Pesticide Use and Bird Activity on Selected Golf Courses in B.C.		x					x
1991 Guide to Chemical Weed Control (annual publication)		x					
Non-Agricultural Pesticides: Risks & Regulations		x					
Greenhouse System for Determining Pesticide Movement from Golf Course Greens			x				
Urban Areas Curb Non-Point Runoff			x				
Characteristics of Pesticide Runoff from Golf Links			x		x		
Rainfall Runoff Characteristics and Risk Assessment of Agro-Chemicals Used in Golf Links			x		x		
Greening of Greens		x			x	x	x
Effects of Nutrient Subsidies from Groundwater to Nearshore Marine Ecosystems off the Island of Hawaii			x				
Accumulation and Excretion of Pesticides Used in Golf Courses by Carp and Willow Shiner							x
Groundwater Contamination in Japan			x				
Wetland Preservation - Par for the Course						x	x
Woodloch Springs: Working Together for Wetland-Sensitive Planning						x	x
Construction of 18-hole Golf Course Facility, Evan Thomas Creek Area, Kananaskis Country						x	x
Groundwater Monitoring Study for Pesticides and Nitrates Associated with Golf Courses on Cape Cod				x			
Poisoning of Wild Birds by Organophosphate and Carbamate Pesticides							x
Areawide Waste Treatment and Erosion Control Planning		x			x		
Flood Plains for Open Space and Recreation						x	x
Mercury Pollution of Golf Course Lakes		x	x				x
Role of Open Spaces in Flood Plain Management						x	x
Effect of Recreation on Water Quality			x				
Mercury Levels in Fishes from Some Missouri Lakes with and without Known Mercury Pollution		x	x				x
Comments Sought by EPA on 2nd Phase of Permit Program for Stormwater Discharges					x		
Golf Blight: Green Deserts for Select Few Menace Developing Countries' Environments							x
Potential Leaching of Herbicides Applied to Golf Course Greens				x			
An Integrated Approach to the Management of Urban Canada Goose Depredations							x
Identification of Residual Pesticides in Water by GC/QPMS			x				
Distribution of Pesticide in River Water from Golf Links			x		x		
Assessment of a New Jersey Lake Contaminated with Fenamiphos			x				x
Monitoring Groundwater for Pesticides at a Golf Course – A Case Study				x			
Hazards of the Game							x
Golf Course Erosion Control					x		
Recent Poisonings of Wild Birds by Diazanon and Carbofuran		x					x
Integrated Pest Management for Turfgrass and Ornamentals	x	x	x		x		x
Pesticides in Fish from a Hawaiian Canal			x				x

The paper entitled *Surface Runoff from Turf* discussed some of the observations and/or conclusions of research efforts relating to the effects of turf on surface water movement. Overall, it was concluded that turf can provide stabilizing effects with to respect runoff quantity and quality: runoff rates are decreased, runoff initiation times are increased and sediment loss and nutrient and pesticide levels are reduced. As untreated turf buffer strips have been shown to be effective in achieving these benefits, some jurisdictions have recommended buffer strips between treated fields and receiving waterbodies. The sodding, rather than seeding, of critically-sloped areas during the initial stages of construction has also been found to significantly reduce runoff. Finally, it was noted that the quantity of pesticides emanating from a turf site in surface waters will be dependent on a number of factors. They include: the amount of pesticide applied; rate of pesticide degradation; soil adsorptive tendencies; pesticide volatilization; pest pressure; rainfall intensity; topography; and landscape design.

The paper, *Development of an IPM Program for Turfgrass*, provided an overview of the purpose of integrated pest management programs, listed key components of a management system and provided brief examples of IPM strategies for high management turf, such as greens and tees, and also low and medium management turf. The purpose of integrated pest management was defined as:

> "... the coordinated use of pest and environmental information with available pest control methods to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property and the environment."

The steps deemed necessary for the development of a management system were:

1. Define the roles of those involved in the management system and establish communication between them.

2. Determine the management objectives.

3. Set action thresholds.

4. Monitor the site regularly to determine when the action threshold has been reached and the effectiveness of any actions taken.

5. Make the site environment incompatible with pest needs.

6. Use the appropriate pesticide (with respect to maximizing pest contact time, while minimizing the hazard to people, property and the environment).

7. Evaluate the results of habitat modification and pesticide use.

8. Keep written records of pest management objectives, monitoring methods and results, actions taken and the results of actions taken.

The elements of this paper's plan for high management turf focussed on pest-resistant grass varieties, pest control alternatives (ie. biological, mechanical controls), irrigation practices, pesticide selection and application, monitoring and education.

It was noted that the EPA has proposed the development of an IPM demonstration project at several courses in the northeastern United States -- the high profile of golf courses and their need for high levels of management have made courses targets of environmental concerns. In addition, cooperation between the Massachusetts government, universities and golf course superintendents association has resulted in the implementation of IPM programs at golf courses across the state.

The final paper of direct relevance to this study was entitled *Integrated Pest Management in the Golf Course Industry: A Case Study and Some General Considerations*. The case itself is not particularly applicable to this study as it discusses the experiences of a particular development in addressing the myriad of U.S. environmental regulations. However, as part of this paper the advantages of the IPM approach were discussed.

Five advantages were highlighted. The first one was that IPM offers better control: the encouragement of natural pest predators offers more effective control, as the risk of killing beneficial organisms through the use of non-selective chemical pesticides is reduced. Secondly, pest resistance is avoided: excessive use of chemicals can lead to the development of resistant organisms and increased chemical requirements. Healthier turf is also a benefit of the IPM approach: increased chemical use increases the risk of misuse or mishaps, potentially causing turf stress or decreasing turf quality. Safety and cost factors can improve: with every chemical application avoided, the associated human and environmental risks are avoided and cost savings are realized. Finally, the IPM approach furthers professionalism: an IPM calls on an understanding of agronomics and management skill to further the long term viability of land, thus highlighting the value of a good superintendent.

5.2 GOVERNMENT INITIATIVES

The investigation into the efforts of regulatory agencies with respect to the development of golf course Best Management Practices included contact with the Great Lakes Pollution Prevention Office (Ontario), King County Environmental Division (Washington), Washington State Department of Ecology and the City of Palo Alto Environmental Compliance Division (California).

City of Palo Alto Environmental Compliance Division

California, out of all of the U.S. states, perhaps has made the greatest effort towards addressing the environmental impacts of golf courses. However, the BMPs developed in that jurisdiction generally have limited relevance to B.C., primarily due to climatic differences (16). For this reason, the attempts to contact Palo Alto's Environmental Compliance Division were not pursued further.

Great Lakes Pollution Prevention Office

The Great Lakes Pollution Prevention Office, an initiative of Canada's Green Plan, provides training, technical assistance and information regarding pollution prevention initiatives. While not responsible for the development of pollution prevention guidelines, the Office is a valuable source of information from throughout North America. The Office conducted a search of documents pertaining to golf course Best Management Practices and was able to provide a number of relevant publications and contacts. These included the USGA Green Section publications and information on the Audobon Cooperative Sanctuary System. These are discussed in Sections 5.3 and 5.4 respectively.

No initiatives directed specifically towards pollution prevention at Ontario golf courses could be found through either the Pollution Prevention Office or the Ontario Ministry of Environment. However, Ontario's Ministry of Agriculture has published *Recommendations for Turfgrass Management* (11). These recommendations are intended for a range of turf uses: from nursery sod and home lawns to athletic fields and golf courses. The 1993 document presents information regarding:

- pesticide use
  (ie. health and safety precautions with respect to pesticide storage, handling and application; pest resistance; waste disposal; and relevant publications)
- soil management and fertilizer use
  (ie. soil sampling, plant analysis, fertilizer use)
- turf management
  (ie. turfgrass species and varieties, renovation and retardation; turf establishment; and cultural and chemical control of insects, disease and weeds)

Again, the specific initiatives of Ontario are of limited relevance to B.C. due to the generally greater temperature and humidity extremes in Ontario (ie. colder and dryer winter months and hotter and more humid summers) and the greater number of pests to be contended with.

Washington State Department of Ecology

The initiatives of Washington State are of greatest interest to this study, as its climate, topography and geology most closely resemble B.C.'s. Discussion with a representative of the Washington State Department of Ecology revealed that the regulation of golf course activities typically falls within the mandate of the Counties. The State is currently focussing its attention on irrigated agriculture and has not developed any guidelines specifically for golf courses (12). The State has however indirectly addressed aspects of golf course operation as part of their *Stormwater Management Manual for the Puget Sound Basin* (13).

The Manual addresses all activities potentially affecting surface water quality. Thus, it contains a section addressing the water quality concerns associated with golf courses. Activities for which recommendations are provided include lawn management, irrigation, fertilizer and pesticide use and weed suppression. Courses are also asked to comply with all other relevant BMPs in the manual: the stormwater treatment BMPs for parking lots, the integrated pest management BMPs and BMPs relating to pesticide use, storage and spill control.

King Country Environmental Division

A number of people within the King County organization were contacted regarding the document entitled *Best Management Practices for Golf Course Development and Operation* (14) which was developed for the County in 1993. Unfortunately, as a result of the amalgamation of Metro (Seattle) and King County, those individuals extensively involved in the preparation of the document are no longer with the County and could not be reached.

The King County BMPs focus primarily on practices related to the planning and construction of golf courses, with limited discussion of operational practices. The BMPs are thus aimed primarily at proposed courses and not necessarily at existing courses. They are enforceable only in sofar as there are regulations which coincide with the recommended practices (for example, recommendations which also form part of the Sensitive Areas Ordinance, King County Surface Water Design Manual or the State Environmental Policy Act). To increase awareness and hopefully compliance with the document, the King County Environmental Education Group is responsible for distributing the BMP manuals and presenting introductory courses on the material. (15)

The following topics are addressed in King County's BMP document: land use planning and regulatory framework, golf course BMPs and planning, wildlife habitat, water consumption and conservation, hydrology and stormwater control, geology and groundwater, turfgrass maintenance and operation, water quality management and chemical selection. While the BMP manual does cover a wide range of relevant issues, it has come under some criticism. The manual was apparently prepared within a short time period (six months), drawing heavily upon guidelines applicable to a national scale. As a result, many in the turf industry feel that the recommended practices are not necessarily relevant or effective in King County (16).

It is the responsibility of the various cities and counties in Washington State to have some form of a stormwater management program in place. This can entail simply adopting the State stormwater management manual, or a modification thereof, or developing their own manual. In the case of King County, the County developed its own *Stormwater Pollution Control Manual* (17). This Manual contains BMPs related to integrated pest management and herbicide and pesticide use, as well as recommending compliance with the County's Golf Course BMP Manual. The stormwater manual is however only part of a voluntary compliance program. Active enforcement of the BMPs, and any further necessary measures to correct polluting conditions, only occurs in the event that complaints are received regarding a business' impact on surface water quality.

Other Initiatives in Washington State

The Seattle Water Department, the Everett Public Works Department and Tacoma City Water have jointly produced a brochure providing information on the principles of turfgrass management: *Principles of Turfgrass Management: Water Use and the Healthy Lawn* (18). The brochure is directed towards both landscape professionals and home gardeners, however, it is relatively straightforward and is likely intended more for private lawn care. Because it is based on research conducted in western Washington at the Washington State University Research and Cooperative Extension Program, it is considered more applicable to this jurisdiction than information derived from other parts of the country. Topics covered include turfgrass needs, problems and solutions (ie. sampling, thatch depth, compaction, overseeding, topseeding, etc.); turfgrass types suitable to western Washington and their characteristics; and irrigation methods.

Dr. S. Brauen, a researcher in the Washington State University Cooperative Extension Program, is actively involved in golf course operation and management issues throughout the State. With respect to Best Management Practice manuals, he is aware of only the King County initiative. Thurston County in central Washington State apparently also has some restrictions affecting golf courses. The Thurston County restrictions pertain to the use of certain pesticides and while aimed at golf courses, are applicable to all commercial turf applications. (16)

British Columbia

In B.C., the only environmental guidelines specifically for golf courses were developed by B.C. Environment in 1992. At this time, the Fish and Wildlife Management Branch developed a document entitled *Guidelines to Protect, Maintain and Enhance Fish and Wildlife Habitat on and adjacent to Proposed Golf Course Developments and Existing Course Re-Developments on Lowland Areas* (19). While these guidelines were developed for Region 2 of B.C. (covering approximately the Lower Mainland to Boston Bar), for the most part they identify generic issues related to course development. The Guidelines discuss leavestrips, fairway orientation with respect to streams, stream crossings, integrated pest management (in very general terms), water hazard design and course construction materials.

(Note: With respect to wildlife considerations, there is also a 1992 B.C. study entitled *A Survey of Pesticide Use and Bird Activity on Selected Golf Courses in B.C.* (30). It provides a limited inventory of pesticide use on courses throughout the province, discusses the potential impacts of pesticides on birds and provides some recommendations for encouraging and safe-guarding bird life.)

5.3 GOLF ASSOCIATIONS

The various North American associations dedicated to the golf industry appear to be active in attempting to address the environmental concerns raised with course construction and operation.

The Royal Canadian Golf Association has developed three sets of guidelines as part of their *Environmental Guidelines for Canadian Golf Clubs* (20). One set of guidelines is directed towards golfers, the second, course designers and developers, and the third, golf course directors, managers and superintendents. Because these guidelines are intended to be applicable on a national scale, they are out of necessity quite general.

In the U.S., a number of national associations have established environmental protection initiatives. These include the U.S. Golf Association (USGA), the American Society of Golf Course Architects and the Golf Course Superintendents Association of America.

The U.S. Golf Association, through its Green Section, has sponsored and continues to sponsor numerous studies evaluating the effects of turfgrass management and golf course development on the environment. These research efforts are documented in numerous publications including, to name a few, *Golf Course Management & Construction: Environmental Issues,* annual environmental/turfgrass research summaries, the *USGA Green Section Record* (turfgrass management publication published six times annually) and *Wastewater Reuse for Golf Course Irrigation*. While there are no documents devoted to integrated pest management or best management practices, these topics are regularly addressed as part of the aforementioned publications.

The American Society of Golf Course Architects has published: *An Environmental Approach to Golf Course Development*. This document addresses the environmental issues often encountered in the development of golf courses and provides eleven case studies illustrating the environmental issues faced and the measures taken.

Journal articles and other publications on various topics associated with environmental issues are available through the publications department of the Golf Course Superintendents Association of America. The Association itself however has not developed guidelines for BMP plans or IPM programs.

The Pacific Northwest Golf Course Superintendents Association, whose jurisdiction encompasses the area from the Pacific coast to the Cascade Mountains in Washington State, was contacted regarding their environmental initiatives. They also have not yet developed any guidelines or recommendations for golf course management nor are they aware of anything having been developed by any other agencies in their jurisdiction or neighbouring jurisdictions (22).

5.4 OTHER ASSOCIATIONS

The Audobon Society, in cooperation with the Royal Canadian Golf Association and the U.S. Golf Association, has developed a Cooperative Sanctuary Program for golf courses to help promote ecologically sound land management and conserve natural resources. Upon registering with the Society and completing a resource inventory, the Society will develop a management strategy for the golf course, recommending projects in the area of integrated pest management, water conservation and wildlife habitat enhancement. Upon achieving a high degree of environmental quality on a course, a Certificate for Achievement may be granted in categories such as Water Quality Management, Integrated Pest Management, Water Conservation, Environmental Planning, Wildlife and Habitat Management and Member/Public Involvement.

The Iowa State University and University of Minnesota Extension Programs have jointly published a document on turfgrass management: *Turfgrass Management for Protecting Surface Water Quality* (23). This booklet provides information on responsible fertilizer and pesticide use and the mechanisms of fertilizer and pesticide transfer to ground- and surface water. While the information is directed primarily towards lawns, reference is made to golf course turf management. The document draws upon over 60 publications for its information and guidelines. It points to research findings that show that not only does healthy turf reduce runoff volumes and increase runoff initiation rates, but that with responsible application practices the leaching or runoff of nutrients and pesticides is minimal. The document concludes with:

> "Protecting surface water and groundwater is not something to be taken lightly. But neglecting turf areas for fear of introducing nutrients and pesticides into water supplies is not a way to protect these resources. Properly maintaining turfed areas with appropriate but modest use of fertilizers and pesticides will do more to protect water resources than to hurt them."

6.0 ECONOMIC IMPACTS OF BMP IMPLEMENTATION

The economic analysis of Best Management Practice (BMP) implementation, particularly on a quanitative basis, is difficult due to the site specific nature of golf course development and operation and the number of factors requiring evaluation. Several persons actively involved in the study or management of the golf course industry across North America were contacted regarding economic impact information (either of a qualitative or quantitative nature): Mr. R. Farentino, turfgrass extension specialist at Cornell University, Dr. G. Stahnke, turfgrass extension specialist at Washington State University, Ms. K. Erusha of the USGA and Mr. B. Wick, Executive Director of the Western Canadian Turfgrass Association. Neither were aware of any case studies evaluating the costs/savings of BMP or Integrated Pest Management (IPM) implementation. Attention appears to be currently focussed mainly on the development and evaluation of IPM techniques. (24-27)

6.1 QUANTITATIVE STUDY

One quantitative case study was found through a search of *Golf Course Management* journals (28). Stoneridge Golf Club in Priest River, Idaho has been experimenting with IPM strategies since 1988. Diseases common to the area include take-all patch, leaf spot, Fusarium blight and pink snow mold. By 1991, the superintendent of the Stoneridge course was able to successfully control three distinct disease outbreaks without the use of synthetic fungicides.

Over the years, the IPM strategies employed at Stoneridge grew to include: the application of solely natural organic fertilizers and biostimulants on the greens (ie. fish emulsion, sea plant extract, bone meal and compost "soup" based on digested sewage sludge and wood waste); use of a water injection aerator; use of screened compost instead of sand as topdressing; application of manures, commercial natural organics, fish emulsion and sea plant extract to the flower beds; control of insects with insecticidal soap, Bacillus thuringensis, pyrethrum and rotenone; elimination of aquatic weeds by skimming or elemental copper additions; and the manual removal of scattered dandelion and plantain plants on green collars and fringes. Pesticides are still necessary for the spot treatment of larger infestations of broadleaves and white clover and for the preventative treatment of pink snow mold in the late fall.

The impacts of these IPM strategies on the golf course's budget have been as follows:

1. Commercial natural organics are slightly higher in cost than high quality synthetics. However, the slow, even release of nutrients provided by the natural organics permitted a 50% reduction in the use of synthetic fertilizers.

2. The cost of the regular foliar application of fish emulsion to the greens was estimated at U.S.$50/year. This only partially countered the large savings generated by decreased synthetic fertilizer use.

Table 6.1
Matrix of Factors Affected by BMP Implementation

Elements Implemented/Improved / ***Costs Affected***	Labour (increased expertise)	Labour (increased time)	Equipment Inventory	Equipment Maintenance	Fertilizer Budget	Pesticide Budget	Water Budget
Irrigation Design	✗	✓	✗	✗	✓	✓	✓
Irrigation Scheduling	✗	✗	-	-	✓	✓	✓
Minimizing Fairway Area	-	✓	✓	✓	✓	✓	✓
Grass Selection	✗	-	-	-	✓	✓	✓
Scouting	✗	✗	✗	✓	-	✓	✓
Slow Release Fertilizers	✗	✓	-	✓	✗	✓	-
Mowing Practices	-	✓	-	✗	✓	✓	✓
Drainage	✗	-	-	-	✓	✓	-
Cultivation	✗	✗	✗	✗	-	✓	✓
Pesticide Application Techniques	✗	-	✗	✗	-	✓	✓

✗ denotes increased cost
✓ denotes decreased cost
\- denotes negligible change in cost

3. The preparation of compost soup incurred 1 manhour/week of labour cost plus $45/year for the commercial product base.

4. Topdressing with screened compost rather than local sands incurred a 1/3 greater cost. This cost was however offset by the savings on fungicides.

At the Stoneridge course it was concluded that, overall, a savings on fertilizer and pesticide expenditures was evidenced.

6.2 QUALITATIVE STUDY

As described earlier, the quantitative study of the economic impacts of BMP/IPM implementation is site specific in nature and requires the evaluation of a number of factors. Thus, obtaining sufficient data from which a generally applicable conclusion may be drawn is a time consuming and costly process. As little quantitative data has been collected to date, a qualitative guide was considered more appropriate at this time.

Table 6.1 presents a matrix of factors affected by the implementation of common BMP techniques and indicates whether a cost increase or decrease would likely be incurred.

The majority of BMP techniques employed would typically require an increase in the level of expertise required by the superintendent or others working with the development or operation of the golf course. Increased expertise is expected to translate to additional training requirements and potentially increased salary expectations.

Irrigation scheduling might require increased time commitment, due to the need to more closely monitor irrigation system performance and the response of the turfgrass. The complexity of the new irrigation scheduling programs might also require additional time commitment.

While minimizing fairway area will minimize labour requirements (fairway maintenance is more labour intensive than the maintenance of rough), more time will need to be spent on scouting, the analysis of scouting results and the carrying out of additional and more frequent cultivation operations.

However, not all of the BMP techniques listed would necessarily result in increased labour costs. Improved irrigation system design would likely require less labour, as coverage and control would be more efficient and effective (ie. a decrease in the amount of time spent hand watering would be expected). Improved mowing practices and the use of slow release fertilizers would both likely achieve a reduction in labour costs. The former would entail using the highest adapted heights for turf, thus decreasing the mowing frequency. The latter would result in fewer fertilizer applications being required.

The majority of the BMP techniques affecting the equipment inventory will increase the capital required. For example, improved irrigation design will likely require more irrigation heads, more wiring and more piping. Carrying out a more comprehensive scouting program may require the purchase of equipment such as dissecting scopes or microscopes. Increased cultivation may require a greater variety of equipment, some of which may be quite costly (ie. water injection equipment). Finally, more expensive equipment may be required for the implementation of improved pesticide application techniques. In contrast however, minimizing fairway area may potentially require fewer fairway maintenance units.

In general, the implementation of BMPs will result in increased maintenance costs. Irrigation audits should be performed on the irrigation system, mowers should be monitored more closely for the quality of cut and the sharpness of blades, cultivation equipment will be used more frequently and pesticide application equipment should be calibrated more often. However, the use of slow release fertilizers will reduce the need to use fertilization equipment and thus the corresponding maintenance requirements. In addition, if an effective scouting program is carried out, the need to use treatment equipment may be reduced.

The effect of BMPs on the budgets for fertilizer, pesticides and water are relatively evident. In general, all BMP practices should result in reduced pest pressure and the reduced use of synthetic pesticides and thus a reduced pesticide budget. For the most part, the effect of BMPs on the fertilizer budget will also be a reduction. However, to a certain extent, the reduction could be offset by the increased expense of slow release fertilizers. The improved efficiency and effectiveness of golf course irrigation system design and irrigation scheduling, the reduced size of fairways, more appropriate cultivar selection, improved scouting (and thus better control of pest pressures which may necessitate increased water use for mitigation), improved infiltration due to cultivation practices, and reduced pesticide application will all result in reduced water use.

The relative impacts of each BMP technique on a golf course's budget must be assessed for each course individually. They will be dependent in part on the degree to which the superintendent carries out the BMP techniques, the success of the techniques and the conditions to be contended with at the course. It should also be recognized that an evaluation that considers only the factors having a market value has limitations. A cost/benefit analysis that considers typically non-quantifiable benefits may ultimately be more valuable to overall golf course management.

7.0 CONCLUSIONS & RECOMMENDATIONS

The golf industry has become the focus of numerous environmental concerns, ranging from surface and ground water quality impacts to impacts on wildlife habitat. The review into existing Best Management Practice (BMP) plans revealed that various golf associations, university extension programs and, to a more limited extent, government programs are involved in addressing these concerns. Many studies evaluating the effects of turfgrass management and golf course development on the environment have been sponsored and many publications documenting these research efforts have been prepared.

Of particular interest is recent research providing evidence of the immobility of several turfgrass fungicides, herbicides and insecticides: investigations at four worst case scenario golf courses in Cape Cod, Massachusetts did not detect any pesticides at toxicologically significant levels. Commonly used pesticides such as dicamba, chlorothalonil, 2,4-D, mecoprop, iprodione and diazinon were rarely detected or not detected at all (23). Research has also indicated that management practices leading to healthy, dense stands of turfgrass can significantly decrease not only the quantity of surface runoff and erosion, but also any nutrient and pesticide losses. Thus, while some golf course studies have found that there is a potential for a build up of metals in on-site soils and that pesticides and elevated nutrient levels may be evidenced in some ground- and surface waters, environmentally responsible management has been found to limit these impacts.

In this study's limited field investigation, pesticides were detected in 3 of the 15 background and rain event water samples. However, none were found at levels above the *Canadian Water Quality Guidelines*. Only one sediment sample revealed a pesticide level above the detection limits. Elevated levels of metals, above B.C. Environment's *Water and Sediment Quality Criteria* or Canada's *Water Quality Guidelines*, were noted in all of the samples collected. High levels of copper were detected in all surface water and sediment samples. High levels of arsenic, lead, chromium and zinc were detected in a number of the samples. The presence of these metals may be attributed to a number of factors: natural sources such as the soil's parent material or human sources such as atmospheric deposition, piping, road run-off, fertilizers or pesticides. In addition, past or present golf course practices could be contributing to the elevated metals levels or upstream agricultural practices or past on-site agricultural practices could also be augmenting these levels. Due to the limited sampling conducted, the actual causes of the elevated metals levels can not be confirmed.

While the BMP review did discover that much research has been conducted into environmental impacts, it also found that there has not been much activity with respect to the development of Best Management Practice guides for the mitigation of environmental impacts. Some golf associations have developed environmental guidelines (ie. the RCGA) and some local, regional and provincial/state governments have also begun to prepare guidelines. However, government initiatives directed specifically towards the environmentally responsible development and operation of golf courses are limited. The majority have provided guidance to golf courses only indirectly, through either stormwater management manuals or pesticide use regulations.

The lack of BMP guides is likely attributable to two factors: i) the site specific nature of BMP plans and ii) the current focus on Integrated Pest Management (IPM).

Golf course management is influenced by a range of site specific variables including climate, soils, geology, turf selection, pest types, the sophistication of the superintendent, the development and operating budget of the course and the demands of the ownership and the players. Thus, management plans derived upon information from another region may not be applicable, because plan details can vary not only between and within biogeoclimatic regions and but also between and within courses. Management plans prepared on a provincial or state wide basis need to be relatively general in nature.

Integrated pest management calls on turfgrass growth, pest and environmental information for the control of unacceptable levels of pest damage by means which are economical and minimize hazard to the environment. While integrated pest management forms an essential component of a management plan and is essential to the economic and environmental sustainability of a golf course, management plans are intended to also address other golf course practices potentially deleterious to the environment (ie. stormwater management, pesticide and fertilizer storage, equipment washing).

This study found that many superintendents already practice aspects of environmentally responsible management (ie. Integrated Pest Management practices or Best Management Practices). However, because many superintendents have not been able to obtain full stakeholder buy-in nor have they prepared a documented management plan or implemented a formal monitoring and recording program, the full advantages of a management plan have not been realized. In addition, it was found that the application of BMP principles varied considerably with a number of factors including the age and location of the course and the education and initiative of the superintendent.

It may be concluded that the success of a BMP plan will ultimately fall to the superintendent and his/her staff. They are typically not only responsible for developing a plan tailored to a course and the day to day implementation of the plan, but are also responsible for acting as liaison between the golf course and government representatives and addressing the demands of the owners and the players. Therefore, in addition to preparing BMP planning guides to assist superintendents, there is a need for an educational program to provide both the rationale and the tools for implementing plans. In this respect, the role of government could be to: i) assist with education regarding the rationale for implementing BMP plans and ii) direct interested parties to appropriate information sources. For maximum benefit, the educational program should be aimed not only at the practicing superintendents, but also at university extension programs providing advice to industry, colleges training future superintendents, suppliers who are often relied upon for chemical use guidance and owners and players placing demands on the superintendents.

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Appendix A

Golf Course Survey

GOLF COURSE INVENTORY

GENERAL COURSE DATA

Course Name:

Civic Address:

Legal Address:

Phone: Fax:

Municipality:

General Manager:

Phone: Fax:

Superintendent:

Phone: Fax:

Certified Pest Control Manager:

Phone: Fax:

Age of Course:

SITE DESCRIPTION

Please provide copy of current site plan and indicate below the total area occupied by the following:

Facility	*Area*
Total	
Fairways	
Greens	
Tees	
Manicured Rough	
Rough (unmaintained or minimally maintained)	
Water	
Parking Lot	
Clubhouse	
Other Amenities (ie. driving range, etc.):	
1.	
2.	
3.	

DRAINAGE

Nearest Waterbody/Watercourse:

Name:

Distance from Course:

Does the course have an underdrain collection system? Y N

Is golf course equipment washed on-site? Y N

If yes:

Location:

Where does wash water drain: ground storm sewer sanitary sewer other:

What cleaning agents are used?

IRRIGATION WATER

Source:

Annual Volume Drawn:

Does the course have a water rights permit? Y N

If yes:

Water Source:

Annual Licenced Volume:

BEST MANAGEMENT PRACTICES (BMPs) & ENVIRONMENTAL PROTECTION PROGRAMS

Does the course follow documented BMPs or a documented Environmental Protection Program? Y N

If yes, plese provide a copy.

Are course maintenance practices based on recommendations from other agencies, publications, schools? Y N

If yes, please list sources (ie. Audobon Society, RCGA, GCSAA, U.S. EPA, etc.):

1.

2.

3.

WATER MANAGEMENT PROGRAM

Is any water quality monitoring performed? Y N

If yes:

For what agency?

Of what water source: surface water groundwater

Does the course follow a documented water management program? Y N

If yes, please provide a copy; if no, briefly describe water management program followed.

PEST CONTROL

Biriefly describe what "pests" (incl. weeds, molds, insects, etc.) are most problematic for the course and what control techniques (chemical, mechanical, physical, biological, etc.) are used:

CHEMICAL STORAGE

Describe chemical storage (ie. location, secondary containment and/or spill control measures, ventilation, security, drainage, etc.):

CHEMICAL USE DATA SUMMARY

Please list each fertilizer and biocide used in the past 5 years (1990-1994).

Year	Trade Name/Manufactuer	PCP Number/	% Active Ingredient	Form
		Fert. Comp. (N-P-K)		(liquid/granular/powder)

CHEMICAL USE DATA

Please complete table for each biocide and fertilizer used in the past 5 years.

Provide:
- i) number of applications per year
- ii) total amount used per year (please give undiluted quantities in kg or ml; if a mixture of fertilizer and biocide is used, give relative proportions of each)
- iii) list areas to which chemical was applied (ie. greens, aprons, tees, flowers, trees, paths, etc.)
- iv) target "pests"

Trade Name:

	1990	1991	1992	1993	1994
i)					
ii)					
iii)					
iv)					

Trade Name:

	1990	1991	1992	1993	1994
i)					
ii)					
iii)					
iv)					

Appendix B

Chemical Analysis Reports

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5
analytical
service
laboratories
ltd.
FAX (604) 253-6700 Tel (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date:	May 19, 1995
ASL File No.	E8567
Report On:	Fraser River Basin Golf Course Project - Water & Soil Analysis
Report To:	**UMA Engineering Ltd.** 3030 Gilmore Diversion Burnaby, BC V5G 3B4
Attention:	**Ms. Andrea Loewie**
Received:	April 5, 1995

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ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=2);
- Laboratory Replicates (n=1);
- Reference Materials (n=2):

NRC MESS-2 (National Research Council of Canada), Sediment Reference Materials certified for trace metals.

APG Lot 13072/13073 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank, Laboratory Replicate and Standard Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

Chromium results for the NRC MESS-2 sample fell outside of the manufacturer's 95% confidence limits.

Please note that Chromium is often associated with the silicate matrix of the sediment. Because of this, the recovery of this element may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

RESULTS OF ANALYSIS - Water[1,2,3] **File No. E8567**

		A-B (1-6) 95 04 05 10:45	A-P3 (1-4) 95 04 05 10:45	A-FB (1-4) 95 04 05 10:15
Physical Tests				
Conductivity	umhos/cm	145	-	-
pH		7.69	-	-
Total Suspended Solids		45	-	-
Nutrients				
Ammonia Nitrogen	N	0.027	0.027	<0.005
Total Kjeldahl Nitrogen	N	0.91	0.94	<0.05
Total Nitrogen	N	0.92	0.95	<0.05
Nitrite/Nitrate Nitrogen	N	0.008	0.007	<0.005
Dissolved ortho-Phosphate	P	0.012	0.011	<0.001
Total Phosphorus	P	0.143	0.139	<0.001
Bacteriological Tests				
Coliform Bacteria - Fecal		80	80	<2
Total Metals				
Arsenic	T-As	0.0007	0.0008	<0.0001
Cadmium	T-Cd	<0.0002	<0.0002	<0.0002
Chromium	T-Cr	0.002	0.002	<0.001
Copper	T-Cu	0.013	0.013	<0.001
Lead	T-Pb	0.001	0.001	<0.001
Zinc	T-Zn	0.010	0.011	<0.005
Dissolved Metals				
Arsenic	D-As	0.0003	-	-
Cadmium	D-Cd	<0.0002	-	-
Chromium	D-Cr	<0.001	-	-
Copper	D-Cu	0.007	-	-
Lead	D-Pb	<0.001	-	-
Zinc	D-Zn	<0.005	-	-
Herbicides				
Quintozene		<0.0002	-	-
Organic Parameters				
Biochem.Oxygen Demand-Tot	BOD-5	<5	<5	<5
Chemical Oxygen Demand	COD	46	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm), and Coliform.

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water[1,2,3] File No. E8567

		Method Blank H2O
Nutrients		
Ammonia Nitrogen	N	<0.005
Total Kjeldahl Nitrogen	N	<0.05
Total Nitrogen	N	<0.05
Nitrite/Nitrate Nitrogen	N	<0.005
Dissolved ortho-Phosphate	P	<0.001
Total Phosphorus	P	<0.001
Bacteriological Tests		
Coliform Bacteria - Fecal		<2
Total Metals		
Arsenic	T-As	<0.0001
Cadmium	T-Cd	<0.0002
Chromium	T-Cr	<0.001
Copper	T-Cu	<0.001
Lead	T-Pb	<0.001
Zinc	T-Zn	<0.005
Dissolved Metals		
Arsenic	D-As	<0.0001
Cadmium	D-Cd	<0.0002
Chromium	D-Cr	<0.001
Copper	D-Cu	<0.001
Lead	D-Pb	<0.001
Zinc	D-Zn	<0.005
Herbicides		
Quintozene		<0.0002
Organic Parameters		
Biochem.Oxygen Demand-Tot	BOD-5	<5
Chemical Oxygen Demand	COD	<20

		APG Lot 13072/13073	APG Lot 13072/13073 Certified Values
Total Metals			
Arsenic	T-As	0.0100	0.0114 ± 0.00285
Cadmium	T-Cd	0.0430	0.0484 ± 0.009
Chromium	T-Cr	0.091	0.0892 ± 0.0135
Copper	T-Cu	0.022	0.0237 ± 0.00534
Lead	T-Pb	0.140	0.133 ± 0.0278
Zinc	T-Zn	0.094	0.0963 ± 0.0128

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for Coliform.

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3,4] File No. E8567

			A-P1-S 95 04 05 10:30	A-P2-S 95 04 05 11:45	A-P3-S 95 04 05 10:30	A-P3-S LRep. 95 04 05 10:30	Method Blank Soil
Physical Tests							
Moisture		%	65.5	47.4	57.6	-	-
Nutrients							
Total Nitrogen	N	%	0.20	0.10	0.16	-	<0.5
Total Phosphorus	P		40	19	47	-	<0.5
Total Metals							
Arsenic	T-As		7.70	3.89	6.30	6.21	<0.05
Cadmium	T-Cd		0.2	0.2	0.2	0.2	<0.1
Chromium	T-Cr		42.1	31.2	31.8	33.3	<1.0
Copper	T-Cu		90.9	25.3	68.9	67.3	<1.0
Lead	T-Pb		9.7	5.5	8.4	8.2	<2.0
Zinc	T-Zn		185	91.0	131	133	<1.0
Herbicides							
Quintozene			<0.01	<0.01	-	-	<0.01
Organic Parameters							
Total Carbon	C	%	2.7	1.3	2.0	-	<0.05
Particle Size							
Gravel	(>2.00mm)	%	12.9	0.00	15.4	-	-
Sand	(2.00mm - 0.063mm)	%	20.0	56.3	21.5	-	-
Silt	(0.063mm - 4um)	%	24.2	21.3	23.6	-	-
Clay	(<4um)	%	42.9	22.4	39.5	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Particle Size, Total Nitrogen, and Total Carbon results are expressed as percent.

[3] < = Less than the detection limit indicated.

[4] LRep. = Laboratory Replicate.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3] **File No. E8567**

		NRC MESS-2	NRC MESS-2 Certified Values	
Total Metals				
Arsenic	T-As	21.2	20.7	± 0.8
Cadmium	T-Cd	0.2	0.24	± 0.01
Chromium	T-Cr	45.0	106	± 8
Copper	T-Cu	38.0	39.3	± 2.0
Lead	T-Pb	21.0	21.9	± 1.2
Zinc	T-Zn	170	172	± 16

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per dry kilogram.

[2] < = Less than the detection limit indicated.

[3] NRC MESS-2 is a Certified Reference Material from the National Research Council of Canada for trace metals.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed., published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analyses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed., published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103°C.

Total Nitrogen and Phosphorus in Sediment/Soil

This procedure involves the acid digestion of the sample to produce a total extract. Nitrogen and phosphorus are then determined by colorimetry. These analyses are sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

***Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium** are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.*

Total Carbon in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9060A (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a total carbon analysis using a Leco induction furnace. This analysis is sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Pesticides/Herbicides in Sediment/Soil

These analyses are based on the method published in the "Journal of the Association of Official Analytical Chemists" Vol. 74, No. 3, 1991. The procedure involves the extraction of the sample into an Acetone/Water mixture and then further partitioning of the extract into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analyses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Sediment/Soil Particle Size Distribution

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton 1978. The procedure involves oven-drying prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

End of Report

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical service laboratories ltd.

ASL

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: May 19, 1995

ASL File No. E8627

Report On: Fraser River Basin Golf Course
Project - Water & Soil Analysis

Report To: **UMA Engineering Ltd.**
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

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~~HF~~ IF

Attention: **Ms. Andrea Loewie**

Received: April 7, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

REMARKS

File No. E8627

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=2);
- Laboratory Replicates (n=1);
- Reference Materials (n=2):

NRC BCSS-1 (National Research Council of Canada), Sediment Reference Materials certified for trace metals.

APG Lot 13072/13073 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank, Laboratory Replicate and Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

Chromium results for the NRC BCSS-1 sample fell outside of the manufacturer's 95% confidence limits.

Please note that Chromium is often associated with the silicate matrix of the sediment. Because of this, the recovery of this element may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

RESULTS OF ANALYSIS - Water[1,2,3]

File No. E8627

		B-B (1-6) 95 04 07 10:00	Method Blank H2O	APG Lot 13072/13073	APG Lot 13072/13073 Certified Values
Physical Tests					
Conductivity	umhos/cm	592	-	-	-
pH		7.56	-	-	-
Total Suspended Solids		67	<1	-	-
Nutrients					
Ammonia Nitrogen	N	<0.005	<0.005	-	-
Total Kjeldahl Nitrogen	N	3.93	0.05	-	-
Total Nitrogen	N	3.93	<0.05	-	-
Nitrite/Nitrate Nitrogen	N	<0.005	<0.005	-	-
Dissolved ortho-Phosphate	P	0.022	<0.001	-	-
Total Phosphorus	P	0.254	<0.001	-	-
Bacteriological Tests					
Coliform Bacteria - Fecal		<2	<2	-	-
Total Metals					
Arsenic	T-As	0.0023	<0.0001	0.0099	0.0114 ± 0.00285
Cadmium	T-Cd	<0.0002	<0.0002	0.0456	0.0484 ± 0.009
Chromium	T-Cr	0.003	<0.001	0.094	0.0892 ± 0.0135
Copper	T-Cu	0.012	<0.001	0.022	0.0237 ± 0.00534
Lead	T-Pb	0.002	<0.001	0.128	0.133 ± 0.0278
Zinc	T-Zn	<0.005	<0.005	0.092	0.0963 ± 0.0128
Dissolved Metals					
Arsenic	D-As	0.0015	<0.0001	-	-
Cadmium	D-Cd	<0.0002	<0.0002	-	-
Chromium	D-Cr	0.002	<0.001	-	-
Copper	D-Cu	0.009	<0.001	-	-
Lead	D-Pb	0.001	<0.001	-	-
Zinc	D-Zn	<0.005	<0.005	-	-
Herbicides					
Quintozene		<0.0002	<0.0002	-	-
Thiophanate methyl		<0.0002	<0.0002	-	-
Organic Parameters					
Biochem.Oxygen Demand-Tot	BOD-5	11	<5	-	-
Chemical Oxygen Demand	COD	102	<20	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Coliform.

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3,4] File No. E8627

			B-P1-S	B-P2-S	B-P2-S LRep.
			95 04 07 10:00	95 04 07 10:00	95 04 07 10:00
Physical Tests					
Moisture %			65.5	61.4	-
Nutrients					
Total Nitrogen	N	%	0.56	0.46	-
Total Phosphorus	P		6.0	11	-
Total Metals					
Arsenic	T-As		5.50	7.38	7.28
Cadmium	T-Cd		0.4	0.4	0.4
Chromium	T-Cr		56.7	62.5	64.4
Copper	T-Cu		30.1	33.5	31.2
Lead	T-Pb		10.7	14.5	12.3
Zinc	T-Zn		87.5	90.7	90.5
Herbicides					
Quintozene			<0.01	<0.01	-
Thiophanate methyl			<0.01	<0.01	-
Organic Parameters					
Total Carbon	C	%	7.1	7.1	-
Particle Size					
Gravel	(>2.00mm)	%	4.80	4.90	-
Sand	(2.00mm - 0.063mm)	%	2.10	12.7	-
Silt	(0.063mm - 4um)	%	44.4	36.8	-
Clay	(<4um)	%	48.7	45.6	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides, and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Particle Size, Total Nitrogen, and Total Carbon results are expressed as percent.

[3] < = Less than the detection limit indicated.

[4] LRep. = Laboratory Replicate.

			Method Blank Soil
Nutrients			
Total Nitrogen	N	%	<0.5
Total Phosphorus	P		<0.5
Total Metals			
Arsenic	T-As		<0.05
Cadmium	T-Cd		<0.1
Chromium	T-Cr		<1.0
Copper	T-Cu		<1.0
Lead	T-Pb		<2.0
Zinc	T-Zn		<1.0
Herbicides			
Quintozene			<0.01
Thiophanate methyl			<0.01
Organic Parameters			
Total Carbon	C	%	<0.05

		NRC BCSS-1	NRC BCSS-1 Certified Values
Total Metals			
Arsenic	T-As	9.9	11.1 ± 1.4
Cadmium	T-Cd	0.2	0.25 ± 0.04
Chromium	T-Cr	31.0	123 ± 14
Copper	T-Cu	16.7	18.5 ± 2.7
Lead	T-Pb	19.5	22.7 ± 3.4
Zinc	T-Zn	111	119 ± 12

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides, and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Total Nitrogen and Total Carbon results are expressed as percent

[3] < = Less than the detection limit indicated.

[4] NRC BCSS-1 is a Certified Reference Material from the National Research Council of Canada for trace metals.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed., published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analyses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed., published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103°C.

Total Nitrogen and Phosphorus in Sediment/Soil

This procedure involves the acid digestion of the sample to produce a total extract. Nitrogen and phosphorus are then determined by colorimetry. These analyses are sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

***Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium** are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.*

Total Carbon in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9060A (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a total carbon analysis using a Leco induction furnace. This analysis is sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Pesticides/Herbicides in Sediment/Soil

These analyses are based on the method published in the "Journal of the Association of Official Analytical Chemists" Vol. 74, No. 3, 1991. The procedure involves the extraction of the sample into an Acetone/Water mixture and then further partitioning of the extract into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analyses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Sediment/Soil Particle Size Distribution

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton 1978. The procedure involves oven-drying prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

End of Report

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CHEMICAL ANALYSIS REPORT

Date: May 29, 1995

ASL File No. E9110

Report On: Fraser River Basin Golf Course Project - Soil & Water Analysis

Report To:
UMA Engineering Ltd.
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: April 28, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas
Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

Canada's 50 BEST MANAGED PRIVATE COMPANIES

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=2);
- Reference Materials (n=2):

NRC MESS-2 (National Research Council of Canada), Sediment Reference Materials certified for trace metals.

APG Lot 13072/13073 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank and Standard Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

Lead results for the NRC MESS-2 sample fell outside of the manufacturer's 95% confidence limits but within the calculated 99.74% control limits.

Chromium results for the NRC MESS-2 sample fell outside of the manufacturer's 95% confidence limits.

Please note that Chromium is often associated with the silicate matrix of the sediment. Because of this, the recovery of this element may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

RESULTS OF ANALYSIS - Water[1,2,3,4]

File No. E9110

		C-B (1-6) 95 04 28	Method Blank H2O	APG Lot 13959/ 13960	APG Lot 13959/ 13960 Certified Values
Physical Tests					
Conductivity	umhos/cm	2120	-	-	-
pH		8.28	-	-	-
Total Suspended Solids		31	-	-	-
Nutrients					
Ammonia Nitrogen	N	0.05	<0.02	-	-
Total Kjeldahl Nitrogen	N	3.10	<0.05	-	-
Total Nitrogen	N	3.11	<0.05	-	-
Nitrite/Nitrate Nitrogen	N	0.007	<0.005	-	-
Dissolved ortho-Phosphate	P	0.661	<0.001	-	-
Total Phosphorus	P	1.40	<0.001	-	-
Bacteriological Tests					
Coliform Bacteria - Fecal		80	<2	-	-
Total Metals					
Arsenic	T-As	0.0037	<0.0001	0.0104	0.0107 ± 0.003636
Cadmium	T-Cd	<0.0002	<0.0002	0.0355	0.0365 ± 0.00459
Chromium	T-Cr	0.005	<0.001	0.105	0.0961 ± 0.00871
Copper	T-Cu	0.012	<0.001	0.054	0.0508 ± 0.00755
Lead	T-Pb	0.001	<0.001	0.154	0.154 ± 0.0300
Zinc	T-Zn	<0.005	<0.005	0.097	0.0976 ± 0.0118
Dissolved Metals					
Arsenic	D-As	0.0028	<0.0001	-	-
Cadmium	D-Cd	<0.0002	<0.0002	-	-
Chromium	D-Cr	0.003	<0.001	-	-
Copper	D-Cu	<0.001	<0.001	-	-
Lead	D-Pb	<0.001	<0.001	-	-
Zinc	D-Zn	<0.005	<0.005	-	-
Herbicides					
Chlorneb		<0.0001	<0.0001	-	-
Quintozene		<0.0002	<0.0002	-	-
Organic Parameters					
Biochem.Oxygen Demand-Tot	BOD-5	19	<5	-	-
Chemical Oxygen Demand	COD	148	<20	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

[4] APG Lot 13959/13960 is a Standard Reference Water from the Analytical Products Group of Belpre, Ohio.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3,4]

File No. E9110

			C-P1-S 95 04 28	C-P2-S 95 04 28	Method Blank Soil 95 04 28 13:00	NRC MESS-2	NRC MESS-2 Certified Values
Physical Tests							
Moisture		%	52.7	69.6	-	-	-
Nutrients							
Total Nitrogen	N	%	0.18	0.31	<0.5	-	-
Total Phosphorus	P		50	26	<0.5	-	-
Total Metals							
Arsenic	T-As		5.04	7.45	<0.05	21.3	20.7 ± 0.8
Cadmium	T-Cd		0.2	0.5	<0.1	0.2	0.24 ± 0.01
Chromium	T-Cr		32.5	61.9	<1.0	46.0	106 ± 8
Copper	T-Cu		103	353	<1.0	40.1	39.3 ± 2.0
Lead	T-Pb		5.7	18.2	<2.0	20.5	21.9 ± 1.2
Zinc	T-Zn		67.9	174	<1.0	170	172 ± 16
Herbicides							
Chlorneb			<0.002	<0.002	<0.002	-	-
Quintozene			<0.005	<0.005	<0.005	-	-
Organic Parameters							
Total Carbon	C	%	1.9	3.2	<0.05	-	-
Particle Size							
Gravel (>2.00mm)		%	0.00	0.00	-	-	-
Sand (2.00mm - 0.063mm)		%	69.8	16.1	-	-	-
Silt (0.063mm - 4um)		%	18.0	53.2	-	-	-
Clay (<4um)		%	12.2	30.7	-	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Particle Size, Total Nitrogen and Total Carbon results are expressed as percent.

[3] < = Less than the detection limit indicated.

[4] NRC MESS-2 is a Certified Reference Material from the National Research Council of Canada.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Total Nitrogen and Phosphorus in Sediment/Soil

This procedure involves the acid digestion of the sample to produce a total extract. Nitrogen and phosphorus are then determined by colorimetry. These analyses are sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The

resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

Total Carbon in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9060A (Publ.# SW-846 3rd ed., Washington, DC 20460). The procedure involves a total carbon analysis using a Leco induction furnace. This analysis is sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Pesticides/Herbicides in Sediment/Soil

These analyses are based on the method published in the "Journal of the Association of Official Analytical Chemists" Vol. 74, No. 3, 1991. The procedure involves the extraction of the sample into an Acetone/Water mixture and then further partitioning of the extract into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton Alberta.

Sediment/Soil Particle Size Distribution

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton 1978. The procedure involves oven-drying prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

End of Report

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CHEMICAL ANALYSIS REPORT

Date: June 15, 1995

ASL File No. E9430

Report On: Fraser River Basin Golf Course Project - Water Analysis

Report To:
UMA Engineering Ltd.
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: May 11, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

CANADA'S 50 BEST MANAGED PRIVATE COMPANIES

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=1);
- Reference Materials (n=1):

APG Lot 13072/13073 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank and Standard Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

RESULTS OF ANALYSIS - Water[1,2,3]

File No. E9430

		A-P1 (1-6)	A-P2 (1-6)
		95 05 11 10:00	95 05 11 11:00
Physical Tests			
Conductivity	umhos/cm	214	178
pH		7.27	7.49
Total Suspended Solids		13	26
Nutrients			
Ammonia Nitrogen	N	<0.005	0.031
Total Kjeldahl Nitrogen	N	1.01	0.66
Total Nitrogen	N	1.02	2.71
Nitrite/Nitrate Nitrogen	N	0.008	2.05
Dissolved ortho-Phosphate	P	0.020	0.012
Total Phosphorus	P	0.160	0.108
Bacteriological Tests			
Coliform Bacteria - Fecal		60	80
Total Metals			
Arsenic	T-As	0.0007	0.0008
Cadmium	T-Cd	<0.0002	<0.0002
Chromium	T-Cr	<0.001	0.001
Copper	T-Cu	0.006	0.009
Lead	T-Pb	<0.001	<0.001
Zinc	T-Zn	<0.005	0.005
Dissolved Metals			
Arsenic	D-As	0.0003	0.0006
Cadmium	D-Cd	<0.0002	<0.0002
Chromium	D-Cr	<0.001	<0.001
Copper	D-Cu	0.005	0.006
Lead	D-Pb	<0.001	<0.001
Zinc	D-Zn	<0.005	<0.005
Herbicides			
Dicamba		0.0005	0.0002
2,4-Dichlorophenoxy Acetic Acid		0.0044	0.0017
Mecaprop		0.0025	0.0014
Quintozene		<0.0005	<0.0005
Organic Parameters			
Biochem.Oxygen Demand-Tot	BOD-5	<5	<5
Chemical Oxygen Demand	COD	40	<20

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Coliform (MPN).

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water[1,2,3]

File No. E9430

		Method Blank	APG Lot 13959/ 13961	APG 13959/ 13961 Certified Values
Nutrients				
Ammonia Nitrogen	N	<0.005	-	-
Total Kjeldahl Nitrogen	N	<0.05	-	-
Total Nitrogen	N	<0.05	-	-
Nitrite/Nitrate Nitrogen	N	<0.005	-	-
Dissolved ortho-Phosphate	P	<0.001	-	-
Total Phosphorus	P	<0.001	-	-
Bacteriological Tests				
Coliform Bacteria - Fecal		<2	-	-
Total Metals				
Arsenic	T-As	<0.0001	0.0104	0.0107 ± 0.00363
Cadmium	T-Cd	<0.0002	0.0387	0.0365 ± 0.00459
Chromium	T-Cr	<0.001	0.105	0.0961 ± 0.00871
Copper	T-Cu	<0.001	0.049	0.0508 ± 0.00755
Lead	T-Pb	<0.001	0.155	0.154 ± 0.0300
Zinc	T-Zn	<0.005	0.096	0.0976 ± 0.0118
Dissolved Metals				
Arsenic	D-As	<0.0001	-	-
Cadmium	D-Cd	<0.0002	-	-
Chromium	D-Cr	<0.001	-	-
Copper	D-Cu	<0.001	-	-
Lead	D-Pb	<0.001	-	-
Zinc	D-Zn	<0.005	-	-
Organic Parameters				
Biochem.Oxygen Demand-Tot	BOD-5	<5	-	-
Chemical Oxygen Demand	COD	<20	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre.

[2] < = Less than the detection limit indicated.

[3] APG Lot 13959/13961 is a Standard Reference Water from the Analytical Products Group of Belpre, Ohio.

METHODOLOGY File No. E9430

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

End of Report

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CHEMICAL ANALYSIS REPORT

Date: June 27, 1995

ASL File No. F1139

Report On: Fraser River Basin Golf Course
Project - Water Analysis

Report To: **UMA Engineering Ltd.**
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: June 7, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

RESULTS OF ANALYSIS - Water[1,2,3] File No. F1139

		B-P1 (1-6) 95 06 07 09:00	B-P2 (1-6) 95 06 07 09:00	C-P1 (1-6) 95 06 07 11:00	C-P2 (1-6) 95 06 07 11:00	C-P2 (1-6) LRep. 95 06 07 11:00
Physical Tests						
Conductivity	umhos/cm	1150	205	533	23.7	-
pH		7.17	7.08	9.55	7.12	-
Total Suspended Solids		31	41	35	5	-
Nutrients						
Ammonia Nitrogen	N	<0.005	0.174	<0.005	<0.005	-
Total Kjeldahl Nitrogen	N	2.37	3.48	2.35	0.29	-
Total Nitrogen	N	2.38	3.50	2.35	0.29	-
Nitrite/Nitrate Nitrogen	N	0.005	0.016	<0.005	<0.005	-
Dissolved ortho-Phosphate	P	0.002	0.027	0.752	0.009	-
Total Phosphorus	P	0.125	0.189	1.07	0.044	-
Bacteriological Tests						
Coliform Bacteria - Fecal		1600	1600	8	2	-
Total Metals						
Arsenic	T-As	0.0015	0.0069	0.0031	0.0002	0.0002
Cadmium	T-Cd	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	T-Cr	0.003	<0.001	<0.001	<0.001	<0.001
Copper	T-Cu	0.005	0.015	0.007	0.007	0.007
Lead	T-Pb	<0.001	0.001	0.001	<0.001	<0.001
Zinc	T-Zn	<0.005	0.007	<0.005	<0.005	<0.005
Dissolved Metals						
Arsenic	D-As	0.0005	0.0043	0.0031	0.0002	-
Cadmium	D-Cd	<0.0002	<0.0002	<0.0002	<0.0002	-
Chromium	D-Cr	<0.001	<0.001	<0.001	<0.001	-
Copper	D-Cu	0.004	0.012	0.005	0.005	-
Lead	D-Pb	<0.001	<0.001	<0.001	<0.001	-
Zinc	D-Zn	<0.005	<0.005	<0.005	<0.005	-
Herbicides						
Chlorneb		-	-	<0.002	<0.002	-
Quintozene		<0.00005	<0.00005	<0.00005	<0.00005	-
Thiophanate methyl		<0.0025	<0.0025	-	-	-
Organic Parameters						
Biochem.Oxygen Demand-Tot	BOD-5	18	8	11	<5	-
Chemical Oxygen Demand	COD	145	151	58	33	-

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[1] Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Coliform (MPN).
[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.
[3] < = Less than the detection limit indicated.
LRep = Laboratory Replicate.

RESULTS OF ANALYSIS - QA Data[1,2,3] **File No. F1139**

		Method Blank
Nutrients		
Ammonia Nitrogen	N	<0.005
Total Kjeldahl Nitrogen	N	<0.05
Total Nitrogen	N	<0.05
Nitrite/Nitrate Nitrogen	N	<0.005
Dissolved ortho-Phosphate	P	<0.001
Total Phosphorus	P	<0.001
Bacteriological Tests		
Coliform Bacteria - Fecal		<2
Total Metals		
Arsenic	T-As	<0.0001
Cadmium	T-Cd	<0.0002
Chromium	T-Cr	<0.001
Copper	T-Cu	<0.001
Lead	T-Pb	<0.001
Zinc	T-Zn	<0.005
Dissolved Metals		
Arsenic	D-As	<0.0001
Cadmium	D-Cd	<0.0002
Chromium	D-Cr	<0.001
Copper	D-Cu	<0.001
Lead	D-Pb	<0.001
Zinc	D-Zn	<0.005
Organic Parameters		
Biochem.Oxygen Demand-Tot	BOD-5	<5
Chemical Oxygen Demand	COD	<20

		APG Lot 13959/13961	APG Lot 13959/13961 Certified Values
Total Metals			
Arsenic	T-As	0.268	0.0107 ± 0.00363
Cadmium	T-Cd	0.0347	0.0365 ± 0.00459
Chromium	T-Cr	0.103	0.0961 ± 0.00871
Copper	T-Cu	0.050	0.0508 ± 0.00755
Lead	T-Pb	0.152	0.154 ± 0.0300
Zinc	T-Zn	0.095	0.0976 ± 0.0118

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[1] Results are expressed as milligrams per litre except for Coliform which is expressed as Most Probable Number (MPN) per 100 mL.

[2] < = Less than the detection limit indicated.

[3] APG Lot 13959/13961 is a Standard Reference Water from the Analytical Products Group of Belpre, Ohio.

METHODOLOGY

File No. F1139

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

End of Report

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

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CHEMICAL ANALYSIS REPORT

Date: July 27, 1995

ASL File No. F1614

Report On: Fraser River Basin Golf Course
Project -Soil & Water Analysis

Report To: **UMA Engineering Ltd.**
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: June 27, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

JL
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REMARKS

File No. F1614

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=2);
- Laboratory Replicates (n=1);
- Reference Materials (n=2):

NRC BCSS-1 (National Research Council of Canada), Sediment Reference Materials certified for trace metals.

APG Lot 13959/13961 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank, Laboratory Replicate and Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

Chromium results for the NRC BCSS-1 sample fell outside of the manufacturer's 95% confidence limits.

Please note that Chromium is often associated with the silicate matrix of the sediment. Because of this, the recovery of this element may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

RESULTS OF ANALYSIS - Water[1,2,3,4]

File No. F1614

		D-B (1-6) 95 06 26 11:30	D-B (1-6) LRep. 95 06 26 11:30	Method Blank Water
Physical Tests				
Conductivity	umhos/cm	111	110	-
pH		7.27	7.25	-
Total Suspended Solids		9	9	-
Nutrients				
Ammonia Nitrogen	N	0.005	0.005	<0.005
Total Kjeldahl Nitrogen	N	0.42	0.40	<0.05
Total Nitrogen	N	0.42	0.40	<0.05
Nitrite/Nitrate Nitrogen	N	<0.005	<0.005	<0.005
Dissolved ortho-Phosphate	P	0.017	0.016	<0.001
Total Phosphorus	P	0.045	0.042	<0.001
Bacteriological Tests				
Coliform Bacteria - Fecal		90	-	<2
Total Metals				
Arsenic	T-As	0.0001	0.0001	<0.0001
Cadmium	T-Cd	<0.0002	<0.0002	<0.0002
Chromium	T-Cr	<0.001	<0.001	<0.001
Copper	T-Cu	0.009	0.009	<0.001
Lead	T-Pb	<0.001	<0.001	<0.001
Zinc	T-Zn	0.045	0.044	<0.005
Dissolved Metals				
Arsenic	D-As	<0.0001	<0.0001	<0.0001
Cadmium	D-Cd	<0.0002	<0.0002	<0.0002
Chromium	D-Cr	<0.001	<0.001	<0.001
Copper	D-Cu	0.005	0.005	<0.001
Lead	D-Pb	<0.001	<0.001	<0.001
Zinc	D-Zn	0.021	0.021	<0.005
Organic Parameters				
Biochem.Oxygen Demand-Tot	BOD-5	51	49	<5
Chemical Oxygen Demand	COD	1430	1420	<20
Herbicides				
Dicamba		<0.0001	-	-
2,4-Dichlorophenoxy Acetic Acid		<0.0001	-	-
Mecaprop		<0.0001	-	-
Quintozene		<0.0001	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

[4] LRep = Laboratory Replicate.

RESULTS OF ANALYSIS - Water[1,2,3] **File No. F1614**

		APG Lot 13959/13961	APG Lot 13959/13961 Certified Values
Total Metals			
Arsenic	T-As	0.0093	0.0107 ± 0.00363
Cadmium	T-Cd	0.0395	0.0365 ± 0.00459
Chromium	T-Cr	0.091	0.0961 ± 0.00871
Copper	T-Cu	0.048	0.0508 ± 0.00755
Lead	T-Pb	0.161	0.154 ± 0.0300
Zinc	T-Zn	0.099	0.0976 ± 0.0118

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre.

[2] < = Less than the detection limit indicated.

[3] APG Lot 13959/13961 is A Standard Reference Water from the Analytical Products Group of Belpre, Ohio.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3]

File No. F1614

			D-P1-S 95 06 26 11:30	D-P2-S 95 06 26 13:00	Method Blank Soil
Physical Tests					
Moisture		%	39.1	42.9	-
Nutrients					
Total Nitrogen		N	0.06	0.09	<0.5
Total Phosphorus		P	30	17	<0.5
Total Metals					
Arsenic	T-As		1.04	1.45	<0.05
Cadmium	T-Cd		<0.1	<0.1	<0.1
Chromium	T-Cr		9.6	12.9	<1.0
Copper	T-Cu		36.7	46.3	<1.0
Lead	T-Pb		3.1	4.1	<2.0
Zinc	T-Zn		113	61.8	<1.0
Herbicides					
Dicamba			0.002	0.002	-
2,4-Dichlorophenoxy Acetic Acid			0.003	0.007	-
Mecaprop			<0.002	<0.002	-
Quintozene			<0.005	<0.005	-
Organic Parameters					
Total Carbon	C	%	0.7	1.6	<0.05
Particle Size					
Gravel (>2.00mm)		%	0.00	0.00	-
Sand (2.00mm - 0.063mm)		%	15.0	22.6	-
Silt (0.063mm - 4um)		%	73.8	58.4	-
Clay (<4um)		%	11.2	19.0	-

		NRC BCSS-1	NRC BCSS-1 Certified Values	
Total Metals				
Arsenic	T-As	9.4	11.1	± 1.4
Cadmium	T-Cd	0.2	0.25	± 0.04
Chromium	T-Cr	39.8	123	± 14
Copper	T-Cu	16.6	18.5	± 2.7
Lead	T-Pb	21.0	22.7	± 3.4
Zinc	T-Zn	114	119	± 12

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Particle Size, Total Nitrogen and Total Carbon results are expressed as percent.

[3] < = Less than the detection limit indicated.

[4] NRC BCSS-1 is a Certified Reference Material from the National Research Council of Canada.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Total Nitrogen and Phosphorus in Sediment/Soil

This procedure involves the acid digestion of the sample to produce a total extract. Nitrogen and phosphorus are then determined by colorimetry. These analyses are sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The

resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

Total Carbon in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9060A (Publ.# SW-846 3rd ed., Washington, DC 20460). The procedure involves a total carbon analysis using a Leco induction furnace. This analysis is sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Pesticides/Herbicides in Sediment/Soil

These analyses are based on the method published in the "Journal of the Association of Official Analytical Chemists" Vol. 74, No. 3, 1991. The procedure involves the extraction of the sample into an Acetone/Water mixture and then further partitioning of the extract into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton Alberta.

Sediment/Soil Particle Size Distribution

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton 1978. The procedure involves oven-drying prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

End of Report

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ASL

CHEMICAL ANALYSIS REPORT

Date:	July 31, 1995
ASL File No.	F1975
Report On:	Fraser River Basin Golf Course Project - Water Analysis
Report To:	**UMA Engineering Ltd.** 3030 Gilmore Diversion Burnaby, BC V5G 3B4
Attention:	**Ms. Andrea Loewie**
Received:	July 12, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

Specialists in Environmental Chemistry

CANADA'S 50 BEST MANAGED PRIVATE COMPANIES

REMARKS File No. F1975

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=1);
- Laboratory Replicates (n=1);
- Reference Materials (n=1):

APG Lot 13959/13961 (Analytical Products Group of Belpre, Ohio), Standard Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank, Laboratory Replicate and Standard Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

ASL

RESULTS OF ANALYSIS - Water[1,2,3,4]

File No. F1975

		D-P1 (1-6) 95 07 11	D-P2 (1-6) 95 07 11	D-P2 (1-6) LRep. 95 07 11
Physical Tests				
Conductivity	umhos/cm	116	126	125
pH		6.78	7.05	7.05
Total Suspended Solids		11	3	3
Nutrients				
Ammonia Nitrogen	N	0.012	0.007	0.007
Total Kjeldahl Nitrogen	N	0.67	0.30	0.30
Total Nitrogen	N	0.68	0.30	0.30
Nitrite/Nitrate Nitrogen	N	0.008	0.005	<0.005
Dissolved ortho-Phosphate	P	0.016	0.005	0.003
Total Phosphorus	P	0.055	0.021	0.026
Bacteriological Tests				
Coliform Bacteria - Fecal		110	130	-
Total Metals				
Arsenic	T-As	0.0001	0.0001	-
Cadmium	T-Cd	<0.0002	<0.0002	-
Chromium	T-Cr	<0.001	<0.001	-
Copper	T-Cu	0.003	0.003	-
Lead	T-Pb	<0.001	0.001	-
Zinc	T-Zn	0.028	<0.005	-
Dissolved Metals				
Arsenic	D-As	<0.0001	<0.0001	-
Cadmium	D-Cd	<0.0002	<0.0002	-
Chromium	D-Cr	<0.001	<0.001	-
Copper	D-Cu	0.001	0.002	-
Lead	D-Pb	<0.001	0.001	-
Zinc	D-Zn	0.013	<0.005	-
Herbicides				
Dicamba		<0.0002	<0.0003	-
2,4-Dichlorophenoxy Acetic Acid		<0.0002	<0.0003	-
Iprodione		0.013	<0.0001	-
Mecaprop		<0.0002	<0.0003	-
Quintozene		<0.0001	<0.0001	-
Chlorthalonil		<0.003	<0.003	-
Organic Parameters				
Biochem.Oxygen Demand-Tot	BOD-5	<5	<5	<5
Chemical Oxygen Demand	COD	20	<20	20

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

[4] LRep. = Laboratory Replicate.

RESULTS OF ANALYSIS - QA Data[1,2,3,4]

File No. F1975

		Method Blank
Nutrients		
Ammonia Nitrogen	N	<0.005
Total Kjeldahl Nitrogen	N	<0.05
Total Nitrogen	N	<0.05
Nitrite/Nitrate Nitrogen	N	<0.005
Dissolved ortho-Phosphate	P	<0.001
Total Phosphorus	P	<0.001
Bacteriological Tests		
Coliform Bacteria - Fecal		<2
Total Metals		
Arsenic	T-As	<0.0001
Cadmium	T-Cd	<0.0002
Chromium	T-Cr	<0.001
Copper	T-Cu	<0.001
Lead	T-Pb	<0.001
Zinc	T-Zn	<0.005
Dissolved Metals		
Arsenic	D-As	<0.0001
Cadmium	D-Cd	<0.0002
Chromium	D-Cr	<0.001
Copper	D-Cu	<0.001
Lead	D-Pb	<0.001
Zinc	D-Zn	<0.005
Organic Parameters		
Biochem.Oxygen Demand-Tot	BOD-5	<5
Chemical Oxygen Demand	COD	<20

		APG Lot 13959/13961	**APG Lot 13959/13961 Certified Values**
Total Metals			
Arsenic	T-As	0.0094	0.0107 ± 0.00363
Cadmium	T-Cd	0.0370	0.0365 ± 0.00459
Chromium	T-Cr	0.100	0.0961 ± 0.00871
Copper	T-Cu	0.054	0.0508 ± 0.00755
Lead	T-Pb	0.160	0.154 ± 0.0300
Zinc	T-Zn	0.101	0.0976 ± 0.0118

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre.

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[3] < = Less than the detection limit indicated.

[4] APG Lot 13959/13961 is a Standard Reference Water from the Analytical Products Group of Belpre, Ohio.

METHODOLOGY

File No. F1975

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

End of Report

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CHEMICAL ANALYSIS REPORT

Date: September 19, 1995

ASL File No. F3242

Report On: Fraser River Basin Golf Course Project - Soil & Water Analysis

Report To: **UMA Engineering Ltd.**
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: August 29, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc. ACL ~~[illegible]~~ LF
Project Chemist

REMARKS File No. F3242

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=2);
- Laboratory Replicates (n=1);
- Reference Materials (n=2):

NRC BCSS-1 (National Research Council of Canada), Sediment Reference Materials certified for trace metals.

APG Lot 14164/14166 (Analytical Products Group of Belpre, Ohio), Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank, Laboratory Replicate and Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

Chromium results for the NRC BCSS-1 sample fell outside of the manufacturer's 95% confidence limits.

Please note that Chromium is often associated with the silicate matrix of the sediment. Because of this, the recovery of this element may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

RESULTS OF ANALYSIS - Water[1,2,3,4]

File No. F3242

		E-B **(1-6)** 95 08 28	**Method** **Blank** **Water**
Physical Tests			
Conductivity	umhos/cm	279	-
pH		8.37	-
Total Suspended Solids		3	-
Nutrients			
Ammonia Nitrogen	N	<0.005	<0.005
Total Kjeldahl Nitrogen	N	0.97	<0.05
Total Nitrogen	N	0.97	<0.05
Nitrite/Nitrate Nitrogen	N	<0.005	<0.005
Dissolved ortho-Phosphate	P	0.002	<0.001
Total Phosphorus	P	0.024	<0.001
Bacteriological Tests			
Coliform Bacteria - Fecal		4	<2
Total Metals			
Arsenic	T-As	0.0012	<0.0001
Cadmium	T-Cd	<0.0002	<0.0002
Chromium	T-Cr	<0.001	<0.001
Copper	T-Cu	0.002	<0.001
Lead	T-Pb	<0.001	<0.001
Zinc	T-Zn	<0.005	<0.005
Dissolved Metals			
Arsenic	D-As	0.0010	<0.0001
Cadmium	D-Cd	<0.0002	<0.0002
Chromium	D-Cr	<0.001	<0.001
Copper	D-Cu	0.002	<0.001
Lead	D-Pb	<0.001	<0.001
Zinc	D-Zn	<0.005	<0.005
Herbicides			
Dicamba		<0.00005	-
2,4-Dichlorophenoxy Acetic Acid		<0.00005	-
Mecaprop		<0.00005	-
Thiophanate methyl		<0.0003	-
Organic Parameters			
Biochem.Oxygen Demand-Tot	BOD-5	<5	<5
Chemical Oxygen Demand	COD	47	<20

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] < = Less than the detection limit indicated.

[3] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

RESULTS OF ANALYSIS - Water[1,2,3] File No. F3242

		APG Lot 14164/14166 & 13959/13961	APG Lot 14164/14166 & 13959/13961 Certified Values	
Total Metals				
Arsenic	T-As	0.0102	0.0107	± 0.00363
Cadmium	T-Cd	0.0378	0.0365	± 0.00459
Chromium	T-Cr	0.105	0.0961	± 0.00871
Copper	T-Cu	0.660	0.698	± 0.0565
Lead	T-Pb	0.141	0.154	± 0.0300
Zinc	T-Zn	0.429	0.408	± 0.0636

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] < = Less than the detection limit indicated.

[3] APG Lots 14164/14166 and 13959/13961 are Reference Waters from the Analytical Products Group certified for trace metals.

RESULTS OF ANALYSIS - Sediment/Soil[1,2,3,4] File No. F3242

			E-P1-S	E-P2-S	E-P2-S LRep.	Method Blank Soil
			95 08 28 12:00	95 08 28 12:00	95 08 28 12:00	
Physical Tests						
Moisture		%	42.4	37.4	-	-
Nutrients						
Total Nitrogen	N		0.05	<0.05	-	-
Total Phosphorus	P		2.2	<1.0	-	-
Total Metals						
Arsenic	T-As		9.61	9.87	10.0	<0.05
Cadmium	T-Cd		<0.1	<0.1	<0.1	<0.1
Chromium	T-Cr		22.7	22.1	22.5	<1.0
Copper	T-Cu		56.1	47.5	50.6	<1.0
Lead	T-Pb		10.1	9.1	9.5	<2.0
Zinc	T-Zn		477	354	253	<1.0
Herbicides						
Dicamba			<0.002	<0.002	-	-
2,4-Dichlorophenoxy Acetic Acid			<0.003	<0.003	-	-
Mecaprop			<0.002	<0.002	-	-
Thiophanate methyl			<0.005	<0.005	-	-
Organic Parameters						
Total Carbon	C	%	0.39	0.25	-	-
Particle Size						
Gravel (>2.00mm)		%	0.00	0.00	-	-
Sand (2.00mm - 0.063mm)		%	4.90	8.60	-	-
Silt (0.063mm - 4um)		%	18.3	29.1	-	-
Clay (<4um)		%	76.8	62.3	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Total Metals, Herbicides and Total Phosphorus results are expressed as milligrams per dry kilogram.

[2] Particle Size, Total Nitrogen and Total Carbon results are expressed as percent.

[3] < = Less than the detection limit indicated.

[4] LRep. = Laboratory Replicate.

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. F3242

		NRC BCSS-1	NRC BCSS-1 Certified Values
Total Metals			
Arsenic	T-As	9.6	11.1 ± 1.4
Cadmium	T-Cd	0.2	0.25 ± 0.04
Chromium	T-Cr	32.0	123 ± 14
Copper	T-Cu	16.4	18.5 ± 2.7
Lead	T-Pb	19.7	22.7 ± 3.4
Zinc	T-Zn	113	119 ± 12

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per dry kilogram.

[2] NRC BCSS-1 is a Certified Reference Material from the National Research Council of Canada.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

Moisture

This analysis is carried out gravimetrically by drying the sample to constant weight at 103 C.

Total Nitrogen and Phosphorus in Sediment/Soil

This procedure involves the acid digestion of the sample to produce a total extract. Nitrogen and phosphorus are then determined by colorimetry. These analyses are sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Metals in Sediment/Soil

These analyses are carried out using procedures that are consistent with the requirements of the appropriate regulatory agencies and adapted from U.S. EPA Method 3050 (Publ. # SW-846, 3rd ed., Washington, DC 20460). The procedures involve a digestion using a combination of nitric and hydrochloric acids. The

resulting extract is bulked to volume with deionized/distilled water. The digested portion is then analysed by a variety of instrumental techniques, which may include specific atomic absorption spectrophotometric techniques (AAS) and/or atomic emission spectrophotometry (ICP), to obtain the required detection limit for each element. Specific details are available upon request.

PLEASE NOTE (When the following elements are reported):

Aluminum, barium, calcium, chromium, iron, magnesium, manganese, molybdenum and vanadium are often associated with the silicate matrix of the sediment. Because of this, the recoveries of these elements may be low using the specified digestion. From an environmental standpoint, this is not usually of concern since the "available" metals are typically the fraction of interest.

Total Carbon in Sediment/Soil

This analysis is carried out in accordance with U.S. EPA Method 9060A (Publ.# SW-846 3rd ed., Washington, DC 20460). The procedure involves a total carbon analysis using a Leco induction furnace. This analysis is sublet to Pacific Soils Analysis Inc. in Richmond, B.C.

Pesticides/Herbicides in Sediment/Soil

These analyses are based on the method published in the "Journal of the Association of Official Analytical Chemists" Vol. 74, No. 3, 1991. The procedure involves the extraction of the sample into an Acetone/Water mixture and then further partitioning of the extract into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analayses are sublet to Enviro-Test Laboratories in Edmonton Alberta.

Sediment/Soil Particle Size Distribution

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton 1978. The procedure involves oven-drying prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

End of Report

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CHEMICAL ANALYSIS REPORT

Date: October 23, 1995

ASL File No. F4218

Report On: Fraser River Basin Golf Course Project - Water Analysis

Report To: **UMA Engineering Ltd.**
3030 Gilmore Diversion
Burnaby, BC
V5G 3B4

Attention: **Ms. Andrea Loewie**

Received: September 29, 1995

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Katherine Thomas, B.Sc.
Project Chemist

Joyce Chow, B.Sc.
Project Chemist

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REMARKS File No. F4218

An extensive quality assurance/quality control program is routinely incorporated with the sample analysis. This program includes the analysis of quality control samples to define precision and accuracy, and to demonstrate contamination control for the type of samples and parameters under investigation. Quality control samples may include method blanks, sample replicates, certified and standard reference materials, and analyte or matrix spikes. For this project, the following quality control analyses were carried out:

- Method Blanks (n=1);
- Reference Materials (n=1):

APG Lot 14890/14892 (Analytical Products Group of Belpre, Ohio), Reference Water certified for trace metals.

The quality control data are reported in the following data tables. This data indicated the following:

Method Blank and Reference Material results for all parameters analysed demonstrated that precision, accuracy, and contamination control met acceptance criteria.

RESULTS OF ANALYSIS - Water[1,2]

File No. F4218

		E-P1 (1-6) 95 09 28 10:00	E-P2 (1-6) 95 09 28 11:00
Physical Tests			
Conductivity (umhos/cm)		313	447
pH		8.46	8.52
Total Suspended Solids		1	22
Nutrients			
Ammonia Nitrogen	N	<0.005	0.009
Total Kjeldahl Nitrogen	N	0.81	0.65
Total Nitrogen	N	0.82	0.65
Nitrite/Nitrate Nitrogen	N	0.005	<0.005
Dissolved ortho-Phosphate	P	0.001	0.001
Total Phosphorus	P	0.025	0.065
Bacteriological Tests			
Coliform Bacteria - Fecal		<2	<2
Total Metals			
Arsenic	T-As	0.0010	0.0005
Cadmium	T-Cd	<0.0002	<0.0002
Chromium	T-Cr	<0.001	<0.001
Copper	T-Cu	0.002	0.004
Lead	T-Pb	0.004	<0.001
Zinc	T-Zn	<0.005	<0.005
Dissolved Metals			
Arsenic	D-As	0.0009	0.0004
Cadmium	D-Cd	<0.0002	<0.0002
Chromium	D-Cr	<0.001	<0.001
Copper	D-Cu	0.002	0.003
Lead	D-Pb	0.001	<0.001
Zinc	D-Zn	<0.005	<0.005
Herbicides			
Dicamba		<0.00005	<0.00005
2,4-Dichlorophenoxy Acetic Acid		<0.00005	<0.00005
Mecaprop		<0.00005	<0.00005
Thiophanate methyl		<0.0005	<0.0005
Organic Parameters			
Biochem.Oxygen Demand-Tot	BOD-5	<5	<5
Chemical Oxygen Demand	COD	44	<20

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).

[2] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

RESULTS OF ANALYSIS - Quality Control[1,2,3,4]

File No. F4218

		Method Blank	APG Lot 14890/14892	APG Lot 14890/14892 Certified Values
Nutrients				
Ammonia Nitrogen	N	<0.005	-	-
Total Kjeldahl Nitrogen	N	<0.05	-	-
Total Nitrogen	N	<0.05	-	-
Nitrite/Nitrate Nitrogen	N	<0.005	-	-
Dissolved ortho-Phosphate	P	<0.001	-	-
Total Phosphorus	P	<0.001	-	-
Bacteriological Tests				
Coliform Bacteria - Fecal		<2	-	-
Total Metals				
Arsenic	T-As	<0.0001	0.0150	0.0152 ± 0.00392
Cadmium	T-Cd	<0.0002	0.0780	0.0764 ± 0.00962
Chromium	T-Cr	<0.001	0.059	0.0557 ± 0.0119
Copper	T-Cu	<0.001	0.062	0.0600 ± 0.0082
Lead	T-Pb	<0.001	0.500	0.482 ± 0.0698
Zinc	T-Zn	<0.005	0.204	0.203 ± 0.0323
Dissolved Metals				
Arsenic	D-As	<0.0001	-	-
Cadmium	D-Cd	<0.0002	-	-
Chromium	D-Cr	<0.001	-	-
Copper	D-Cu	<0.001	-	-
Lead	D-Pb	<0.001	-	-
Zinc	D-Zn	<0.005	-	-
Organic Parameters				
Biochem.Oxygen Demand-Tot	BOD-5	<5	-	-
Chemical Oxygen Demand	COD	<20	-	-

Remarks regarding the analyses appear at the beginning of this report.

[1] Results are expressed as milligrams per litre except where noted.

[2] < = Less than the detection limit indicated.

[3] Coliform results are expressed as Most Probable Number (MPN) per 100 mL.

[4] APG Lot 14890/14892 is a Reference Water from the Analytical Products Group certified for trace metals.

Samples were analyzed by methods acceptable to the appropriate regulatory agency. Outlines of the methodologies utilized are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Ed. published by the American Public Health Association, 1992. Further details are available on request.

Pesticides/Herbicides in Water

These analyses are carried out using an in-house method developed and validated by Enviro-Test Laboratories in Edmonton, Alberta. The procedure involves partitioning of the sample into Dichloromethane. The extract is then concentrated, exchanged into a mobile phase and analysed by High Pressure Liquid Chromatography (HPLC). These analyses are sublet to Enviro-Test Laboratories in Edmonton, Alberta.

Metals in Water

These analyses are carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 18th Edition published by the American Public Health Association, 1992. The procedures involve a variety of instrumental analyses including atomic emission spectrophotometry (ICP) and atomic absorption spectrophotometry (AA) to obtain the required detection limit for each element. Specific details are available on request.

End of Report