Vegetation Mapping (1968 – 2000) of Dust Control Treatment Areas Revelstoke Reach – Upper Arrow Reservoir

March 2002

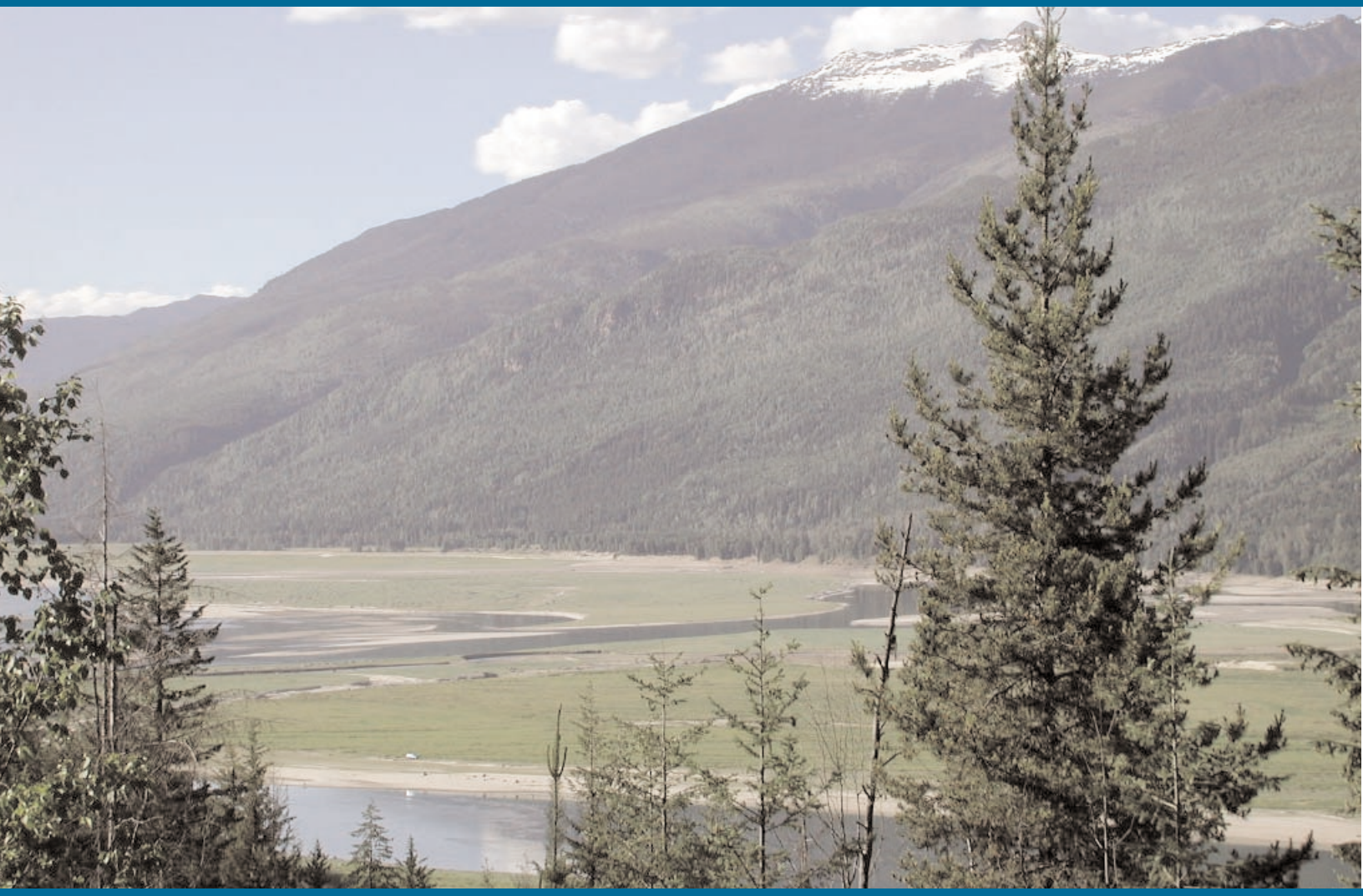


Photo courtesy of Wendy Beauchamp

Prepared by: Anne I. Moody, AIM Ecological Consultants Ltd.

Prepared for: BC Hydro Strategic Environmental Initiatives Program
Evaluation of the Ancillary Benefits of Upper Arrow Reservoir Drawdown Zone Revegetation Project

BC hydro

B.C. Hydro

Strategic Environmental Initiatives Program
Evaluation of Ancillary Benefits of Reservoir Shoreline Revegetation Project

Vegetation Mapping (1968 - 2000) of Dust Control Treatment Areas

Revelstoke Reach - Upper Arrow Reservoir

Prepared by:

Anne I. Moody, M.Sc. R.P. Bio.
AIM Ecological Consultants Ltd.
100 Mile House, B.C.

March 2002

Executive Summary

Since the late 1980's, significant portions of the Revelstoke Reach of Arrow Reservoir have been repeatedly seeded with fall rye for wind erosion control and dust abatement. The seeding has continued for dust control annually, with the program modified each year in response to projected water levels, shifts in dust source locations, and the progression of perennial native vegetation development on previously seeded areas.

An objective of the BC Hydro Strategic Environmental Initiatives Program (SEIP): Evaluation of Ancillary Benefits of Reservoir Draw down Zone Revegetation, is the quantification of aquatic and terrestrial resource contributions arising from the vegetation development associated with the Arrow Dust Control Program. In 1999, BC Hydro initiated an evaluation of the potential benefits associated with the new wetland area under the SEIP Program. The vegetation mapping project was undertaken in 2000, in order to quantify over time, the distribution of perennial native species in previously seeded portions of Revelstoke Reach, south of the town of Revelstoke, B.C. The project included:

- Interpretation of the historical aerial photos (1968, 1977 and 1991) to determine historical vegetation distribution.
- Interpretation of the 2000 aerial photos to determine vegetation species composition and distribution.
- Field checking of 2000 vegetation mapping.
- Overlay of historical and 2000 vegetation data onto the orthophoto base.
- Comparison of 2000 vegetation with historical vegetation, and
- Provision of draft maps to B C Hydro for incorporation and analysis within its GIS system.

Pre-impoundment, the 1,046 ha study area contained a mix of vegetation typical of the predominant land-uses including: agricultural, treed, disturbed (recently cleared), as well as the floodplain and wetland areas. The Keenleyside Dam north of Castlegar was constructed in 1967 and the Arrow Lakes Reservoir was filled to the maximum operating level by mid-1969. The resulting decline in vegetation cover was very dramatic between 1968 and 1977. In the almost 10 years following impoundment, vegetation cover was reduced by 89% in the study area. However, between 1977 and 1991, small areas of sparse vegetation appeared, indicating the development of vegetation adapted to inundation. A 42% increase in vegetated cover was observed in the total vegetated area (from 120 to 170 ha) between 1977 and 1991, followed by an almost 200% increase between 1991 and 2000. This dramatic increase in native, perennial vegetated cover has been attributed to factors associated with the annual fall-rye drill-seeding operations.

The year 2000 mapping revealed that perennial vegetation now dominates about 500 ha of the study area. Three major vegetation groupings, in addition to the annually seeded fall rye, account for most of the current vegetation. These include the communities dominated by grasses, sedges and horsetails. The grass group dominates 75% of the mapped areas, followed by sedge (19%) and horsetail (6%). The perennial wetland vegetation occupying the study area in the year 2000 is a substantial increase over the pre-impoundment floodplain and wetland vegetation types which occupied 365 ha in 1968. Pre-impoundment, most of the land was agricultural or treed, isolated from annual flood effect. Most of the vegetation classified as floodplain (i.e. subject to inundation annually) occurred on the river bars and was most abundant in the central and lower part of the study. The former agricultural areas, previously removed from river influence, are now within the draw down zone of the reservoir and for the most part, are dominated by perennial wetland species.

Integration of the mapping with the GIS-based DTM developed by BC Hydro allowed for an analysis of elevation and vegetation distribution. Patchy vegetation development was observed as low as 431 m, but the majority of vegetation development is minimal until 434 m. Between 434m and 440m (full pool), the plant communities reflect a range of tolerances to inundation and vegetation competition. Incipient vegetation, consisting of newly developing sedge and grass cover, is distributed primarily between 435m and 433m (5 to 7m below full pool). The grass group is the most narrowly focused, with most of the vegetation colonization occurring at 434m as of the year 2000.

Recommendations for further work include:

- Repeated aerial photography and vegetation mapping on a 5 year interval to monitor developing vegetation patterns within Revelstoke Reach, and
- extending the vegetation mapping to cover the remainder of the Upper Arrow draw down zone wetlands to obtain a complete record of the vegetated area within Revelstoke Reach.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance of several BC Hydro staff during the course of this project. Thank-you to Jack Matches, BC Hydro photogrammetry for making available the aerial photographs and orthophotography required for this project and for providing information when needed. The assistance of Wendy Beauchamp in troubleshooting mapping and GIS issues is greatly appreciated. Last but not least, sincere appreciation to Ed Hill for recognizing the need for this endeavour and providing the wherewithal to accomplish it.

1.0 INTRODUCTION

Revelstoke Reach, a portion of Upper Arrow Reservoir, has been annually seeded with fall rye for wind erosion and dust control since 1990. From the initial seeding of some 200-350 ha, the program was expanded to over 1000 ha in 1991. The annual dust control program has continued with some modifications to the area seeded each year (Appendix 1), based on dust sources, projected water levels, and an observed encroachment of native vegetation into previously seeded areas. Although expansion of native vegetation has been observed over the past several years, the only quantification of vegetation spread has been from monitoring of a limited number of long term vegetation plots, established in 1992 (Moody 2002).

This vegetation mapping project was undertaken in order to quantify over time, the distribution of perennial native species[1] in previously seeded portions of Revelstoke Reach. The mapping program did not include annual fall rye seeding but did include reed canary grass which may or may not have been planted in the area prior to the creation of Hugh Keenlyside dam. Reed canary grass is an indigenous B.C. species, common to wetland areas. Agronomic varieties have also been introduced by agricultural practices into wetland areas throughout B.C. The origin of the reed canary grass in Upper Arrow reservoir is unknown.

The major vegetation types existing within the treated portions of the reservoir include:

1. Seeded annual fall rye (not mapped as part of this study)
   This annual agronomic crop is unable to persist from one year to the next except by seed; its growth and maturity is limited by inundation. Seed is only able to develop in those years when the plants are not immersed as was the case in 1992. Annual fall rye distribution is highly dependent on the dates of drill seeding and subsequent water elevations. Depending on the dates of photography, the images may capture some, part or all of the drill seeding.

2. Sedge dominated communities (perennial)
   The predominant species include lenticulate sedge (*Carex lenticularis*) and Columbia sedge (*C. aperta*) as well as a limited number of other native wetland species.

3. Reed canary grass community (perennial)
   Reed canary grass forms tall, sometimes dense stands. A limited understory of sedge and other wetland species is typical of the reed canary grass dominated areas. Native willows and other riparian shrubs also occur in the upper most portions of the community.

4. Horsetail dominated communities (perennial)
   The predominant species usually consist of monotypic stands either scouring rush (*Equisetum hyemale*) or water horsetail (*Equisetum fluviatile*).

[1] Annual – a plant which grows from seed and survives for one season only
Perennial – a plant which lives for two or more years, surviving winter by means of underground storage organs eg. rhizomes or tubers
Native - species indigenous to the area

1.1 Objectives

The goal of the vegetation mapping program was to "*quantify the distribution of vegetation and evaluate the colonization rates by native species*". (TOR – Appendix 2).

Specific objectives were to… "*Identify, map and quantify the distribution of different vegetation types within the study area based on current and historical aerial photos*".

The intent of the vegetation mapping task was to complement objectives identified within the vegetation component of the SEIP Evaluation of Ancillary Benefits of Reservoir Shoreline Revegetation project. Those objectives were:

- to establish a long-term monitoring design on the treated (seeded for dust control) portion of the draw down zone in Revelstoke Reach of the Upper Arrow Reservoir;
- to quantify the biomass contributions of vegetation in the three major plant communities that have developed as a result of the dust control seeding program; including organic inputs, nutrients (nitrogen and phosphorus), and carbon;
- to provide a preliminary characterization of microbial pathways for biomass conversion and subsequent input into the aquatic system; and
- to develop tested data inputs for the ecosystem model linking vegetation and fish.

1.2 Study Area

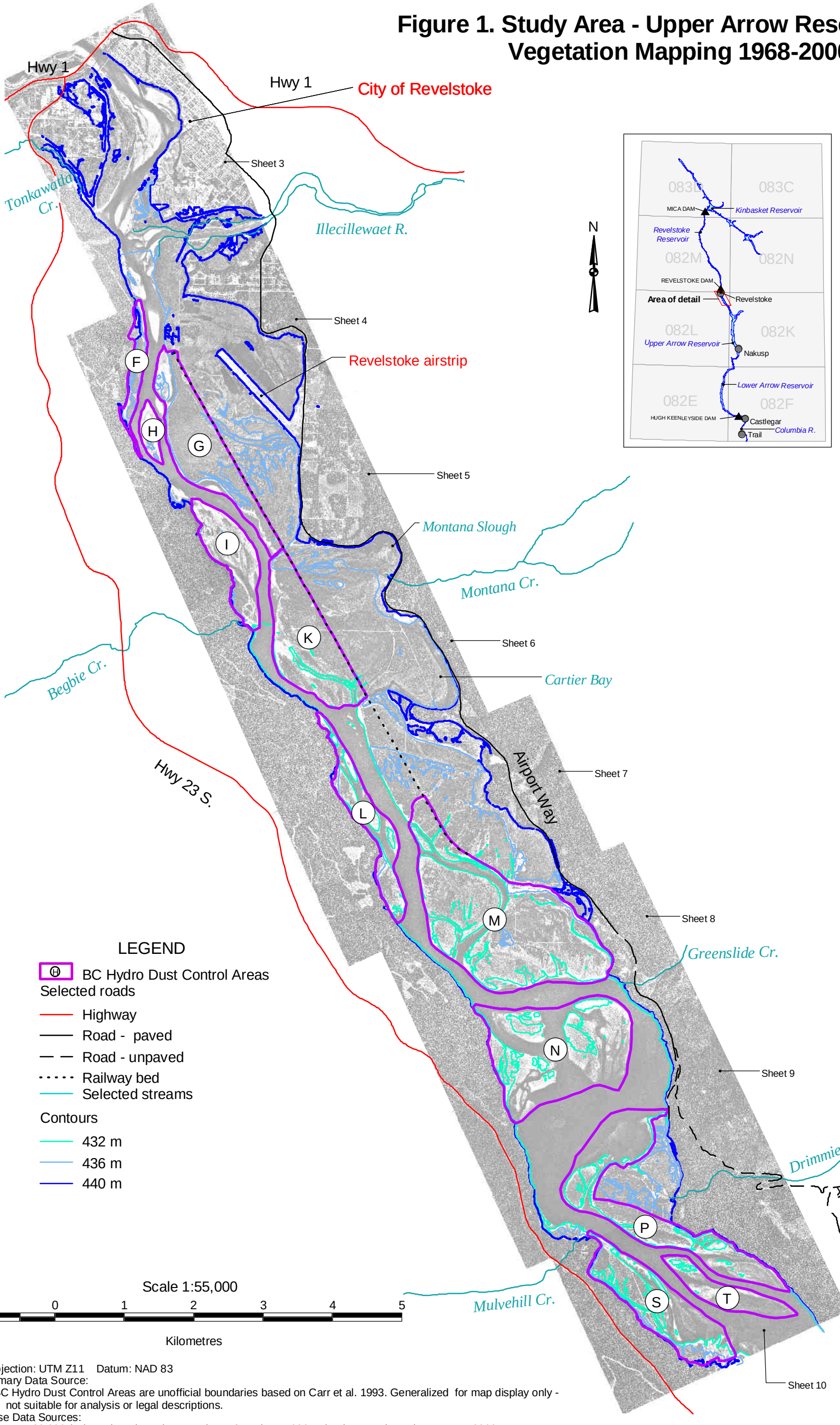
The study area is situated south of the town of Revelstoke, within Revelstoke Reach, the northernmost portion of Upper Arrow reservoir (Figure 1). Specifically, the project was limited to:

> *Previously revegetated areas referenced in previous reports in the Upper Arrow Reservoir. This includes the elevation band from 440m to 435m* (Appendix 2, Figure 1).

Revegetated areas include those seeded and/or planted for the purpose of dust control (also referred to as treatment areas). The limits of the study area (dust control areas) were determined from maps of treatment areas (Carr et. al. 1993). The majority of the revegetation activity initiated in June 1990, occurred between Area "G" and Area "T" (W. Carr, pers. comm).

For the greater part of the study area, the historical railway line serves as the eastern boundary of the mapping. In addition to serving as a convenient geographic marker, the railway bed also has a functional role in bounding the dust control areas. The compaction of the rail-bed and its slightly elevated presence in many areas may serve to delay drainage, thus retaining moisture in the eastern vegetated areas during draw down. This helps to facilitate plant growth and makes the substrates less prone to dust generation. The western boundary of the study area is defined by the steep slopes along the western edge of the reservoir.

Figure 1. Study Area - Upper Arrow Reservoir Vegetation Mapping 1968-2000



Projection: UTM Z11 Datum: NAD 83
Primary Data Source:
BC Hydro Dust Control Areas are unofficial boundaries based on Carr et al. 1993. Generalized for map display only - not suitable for analysis or legal descriptions.
Base Data Sources:
TRIM 1:20,000 (selected roads and streams), BC Hydro 1:5000 orthophotos - photo date June 4, 2000
Contours from BC Hydro DEM, May 24, 2000
GIS and Map Production: Wendy Beauchamp, Consultant. Map produced for AIM Ecological Consultants Ltd. and BC Hydro.
Map Production Date: Feb. 2002 v1.3, modified June 2002 Software: ArcView 3.2

BC hydro

2.0 Methods

2.1 Introduction

The study approach included the following steps:

- Interpretation of the historical aerial photos (1968, 1977 and 1991) to determine historical vegetation distribution.
- Interpretation of the 2000 aerial photos to determine vegetation species composition and distribution.
- Field checking (2001) of mapped (2000) vegetation composition and distribution
- Overlay of historical and 2000 vegetation data (species composition and distribution) onto the orthophoto base (2000 aerial photography).
- Comparison of 2000 vegetation with historical vegetation.
- Provision of draft maps to B C Hydro for incorporation and analysis within their GIS system.

2.2 Air Photo Interpretation

Aerial photos were examined stereoscopically (at 4 power) to obtain maximum information regarding the vegetation cover. Incidental observations of vegetation patterns and notable features were recorded as mapping notes (Appendix 3). Vegetation areas were mapped on a transparent overlay attached to the original photograph. The resulting interpreted image was then scanned, scaled and georeferenced to the 2000 orthophoto base (1:5,000) provided by BCH. The corrected photo images were used as an intermediate layer to allow on-screen digitization of the vegetation data at a standardized scale of 1:5,000. Four separate maps (one for each year documented), were produced for each orthophoto mapsheet and were provided for BC Hydro to incorporate into its GIS system. The summarized GIS maps appear in Appendices 4-7.

Table 1: Aerial Photographs Used for Upper Arrow Reservoir Vegetation Mapping

Year	Film Roll Exposures	Image	Date of Photography	Scale
1968	W1239 Exp. 26695-26715	b & w	May 9, 1968	1:30,000
1977	BR77070 Exp. 442-457	normal colour	Aug. 7, 1977	1:20,000
1991	SRS4528 Exp. 1–204	b & w	Apr. 12, 1991	1:10,000
2000	SRS6201 Exp. 215-450	normal colour	May 24, 2000	1: 5,000

2.3 Limitations of Historical Air Photo Interpretation

The scales of the historical (pre-2000) photography permitted only general interpretations of the vegetation observed in the photos. General categories of land use and the presence of wetlands and floodplain vegetation were identified for the 1968 photography (1:30,000 gray scale photos). Interpretation of 1977 and 1991 photography was limited to the classification of vegetated or unvegetated areas. All of the post-impoundment vegetated areas within the draw down zone were considered as floodplain, equivalent to the mapped 1968 floodplain vegetation. These vegetated draw down zone areas are, for the most part, flooded annually and functioning as floodplain habitats.

2.4 Historical Airphoto Interpretation and Mapping

2.4.1 1968

The 1968 pre-impoundment, small scale photos, were interpreted and the study area was mapped based on discernable land-use patterns:

- Agricultural (pasture, hay meadow or other crop use)
- Disturbed/Cleared (land disturbance evident, recent timber harvesting)
- Industry (vegetated areas surrounding lumber mill)
- Natural vegetation (forb or grassland communities - not obviously modified by agricultural practices)
- Treed
- Floodplain vegetation [sand/gravel bar habitats - typically dominated by shrubs, (primarily willow) and some grasses or sedges. These areas were only seasonally flooded]
- Wetland [sheltered pockets containing cattail or bulrush marsh – static, stable back-channel vegetation with standing water (e.g., Montana Slough). as opposed to floodplain which is only periodically inundated]

2.4.2 1977

For the 1977 photos, vegetation interpretation was for the most part limited to vegetated as opposed to non-vegetated areas. The greatest difficulty occurred in avoiding identification of areas containing dead vegetation as vegetated (i.e., texture on photos indicated the presence of vegetation). However, most of these areas contained dead vegetation as a consequence of inundation. Only areas with visible green (colour photos) were mapped as vegetated.

2.4.3 1991

The 1991 1:10,000 gray-scale photos were taken too early in the growing season to easily interpret growing vegetation. However, we had the additional benefit of photographs and field notes recorded during a 1991 helicopter overview to support interpretations. Stereoscopic interpretation was conducted with 4x magnification to view surface texture characteristics.

Difficulties were encountered in discriminating remnant surficial organic matter (dead) from live vegetation. In the event of confusion, a conservative assumption was made that an area was vegetated if it had a dark colour signature and surface texture indicative of vegetation growth. Not all dark areas were vegetated; most of those lacking surficial texture were merely wet.

A further confounding factor was encountered with the annual fall rye drill seeding program. On bare substrates, the presence of fall rye growth was quite distinct due to its linear (drill-seeded) pattern. Areas of horsetail and fall rye growth combined were sometimes difficult to discriminate, particularly when fall rye was seeded through existing horsetail or sparse areas of growth of other perennial species. This would have resulted in an overestimation of the abundance of native perennial vegetation.

2.4.4 1996

The colour 1996 photos were taken too early in the growing season to show any green vegetation. Therefore, these photos were not used in this study.

2.4.5 **2000**

The year 2000, 1:5000 colour air photos yielded the best information compared to earlier photography. These photos allowed the development of a subjective rating scheme for vegetation characteristics based on plant density and growth (Table 2). Spot checking of species identifications was undertaken by cross checking draft mapped polygons with field observations in June 2001. Slight discrepancies were to be expected due to the 13 months difference between time of photography and field checking, particularly since herbaceous vegetation communities are very sensitive to annual environmental variations. The subjective density ratings were visually checked in June 2001 to confirm that densities observed on aerial photographs matched the ground-based observations for approximate plant height, and canopy cover. These ratings were further confirmed by cross-referencing mapped polygons with previously obtained biomass and stem density information from specific locations within the draw down zone (AIM & Carr 2000, Carr & AIM 2002a). The density ratings and biomass results were integrated with a liberal application of professional judgment to provide generalized biomass values for the dominant vegetation type and densities. These integrated results are presented in the vegetation synthesis report (Carr & AIM 2002b).

Table 2: Vegetation Characteristic Ratings

H	high density, lush vigorous growth
M	moderate density, relatively open canopy, and/or shorter plants than for H
L	low density; short, patchy or sparse growth
I	incipient; vegetation at an initial stage of growth, small plants widely scattered

For each mapped polygon, labels provided information on vegetation density and species composition. Dominant species for an area were listed first, followed by species of lesser abundance. No species abundance, other than for the primary component, is implied by the sequence of species. An example of a 2000 map label follows:

> ***H - Pa Cl Ef***
>
> refers to a high density "H" stand of Reed canary grass (Pa = *Phalaris arundinacea*) with elements of lenticulate sedge (Cl = *Carex lenticularis*) and water horsetail (Ef =*Equisetum fluviatile*).

The area interpreted in this example had patches of sedge and horsetail apparent among the reed canary grass, either within sparse areas or as distinct small patches within the dense community. Reed canary grass, although highly productive and tall, has a rather open signature on the air photos with the denser, (caespitose) lenticulate sedge evident among the stems.

Textural differences are apparent where other species are blended into the community. Some interpretation difficulty was encountered with plant density in areas where fall rye had been seeded through existing sparse vegetation. This was clarified during the subsequent field verification stage.

3.0 RESULTS AND DISCUSSION

The preliminary mapping, which was integrated into BC Hydro's GIS system, yielded precise areas and elevation data for each polygon mapped. Summary results are provided in the following sections and in Appendix 8 (summary table). A complete spreadsheet of the vegetation and elevation data is appended (Appendix 9).

3.1 Vegetation Change Over Time

Overall, in 2000, perennial vegetation occupied almost 500 ha in the treated areas (Table 5). This represents a 52% decline from the pre-impoundment vegetated area of 1,046 ha. The Keenleyside Dam north of Castlegar was constructed in 1967 and the Arrow Lakes Reservoir was filled to the maximum operating level by mid-1969. The resulting decline in vegetation cover was very dramatic between 1968 and 1977. In the almost 10 years following impoundment, vegetation cover was reduced by 89% in the study area. The previously vegetated areas encompassed a whole range of land-use categories including: industrial, disturbed, agricultural as well as the floodplain and wetland areas. Photographs from 1977 and 1991 show that the vegetation cover continued to decline during that interval. However, by 1991 new areas of vegetation cover appeared, indicating the establishment of vegetation adapted to inundation. Only 50 ha of change was observed in the total vegetated area between 1977 (120 ha) and 1991 (170 ha). Between 1991 and 2000, the vegetated area increased by 329 ha. The largest increase occurred in Area "M" with over 100 ha gained since 1991 (Table 3).

Table 3: Summary of Vegetated Areas (ha) by Treatment Area and Year

Dust Control Area	1968	1977	1991	2000
F	18.6	1.7	14.1	14.6
G	123.0	29.7	56.2	117.3
H	0.0	0.0	0.0	3.9
I	19.7	0.6	7.1	14.1
K	102.9	19.0	24.2	100.3
L	42.4	1.9	1.6	20.0
M	301.8	32.9	49.4	150.6
N	138.3	0.0	0.0	3.7
P	146.0	9.0	7.4	44.4
S	116.7	25.1	10.1	29.8
T	36.8	0.0	0.0	0.0
Total	**1,046.1**	**120.1**	**170.0**	**498.7**

The 499 ha of perennial vegetation (wetland species) occupying the study area in the year 2000 is a substantial increase over the pre-impoundment floodplain and wetland vegetation types which occupied 365 ha in 1968 (Table 4). Pre-impoundment, most of the land was agricultural or treed, isolated from annual flood effect. Most of the vegetation classified as floodplain (i.e. subject to inundation annually) occurred on the river bars and was most abundant in the central and lower part of the study area (Areas “M”, “N”, “P” and “T”). The former agricultural areas, previously removed from river influence, are now within the draw down zone of the reservoir and for the most part, are dominated by perennial wetland species. The greatest gains in floodplain vegetation have occurred at treatment areas “G”, “K” and “M” (Table 4). The greatest loss was at area “N”, which has been limited in vegetation re-establishment by its low elevation.

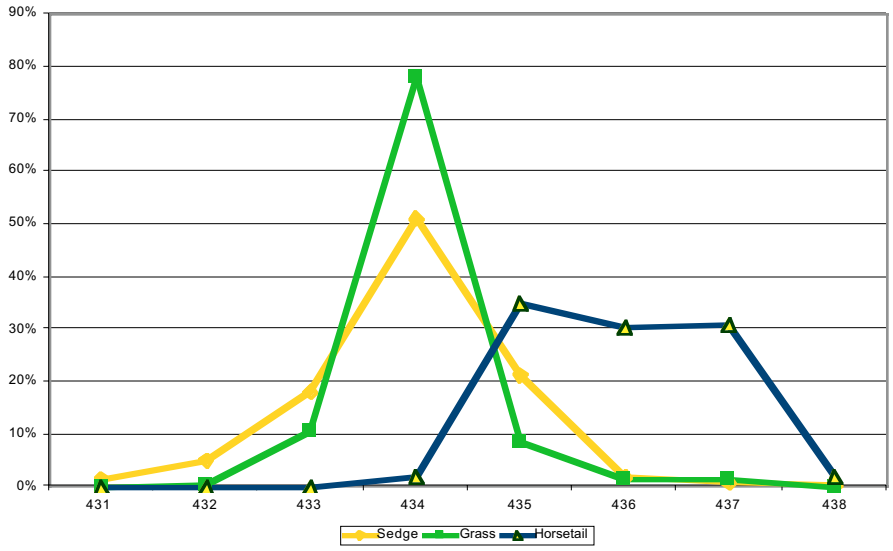
Table 4: Floodplain Vegetation Changes Between 1968 and 2000

Treatment Area	Floodplain Area (Ha) 1968	Floodplain Area (Ha) 2000	Net Change (ha)
F	13.0	14.6	1.6
G	1.3	117.3	115.9
H	0.0	3.9	3.9
I	19.7	14.1	-5.6
K	13.8	100.3	86.5
L	13.8	20.0	6.2
M	103.3	150.6	47.3
N	138.3	3.7	-134.6
P	19.9	44.4	24.5
S	5.1	29.8	24.7
T	36.8	0.0	-36.8
Total	**365.2**	**498.7**	**133.5**

4.2 Species and Elevation Relationships (2000)

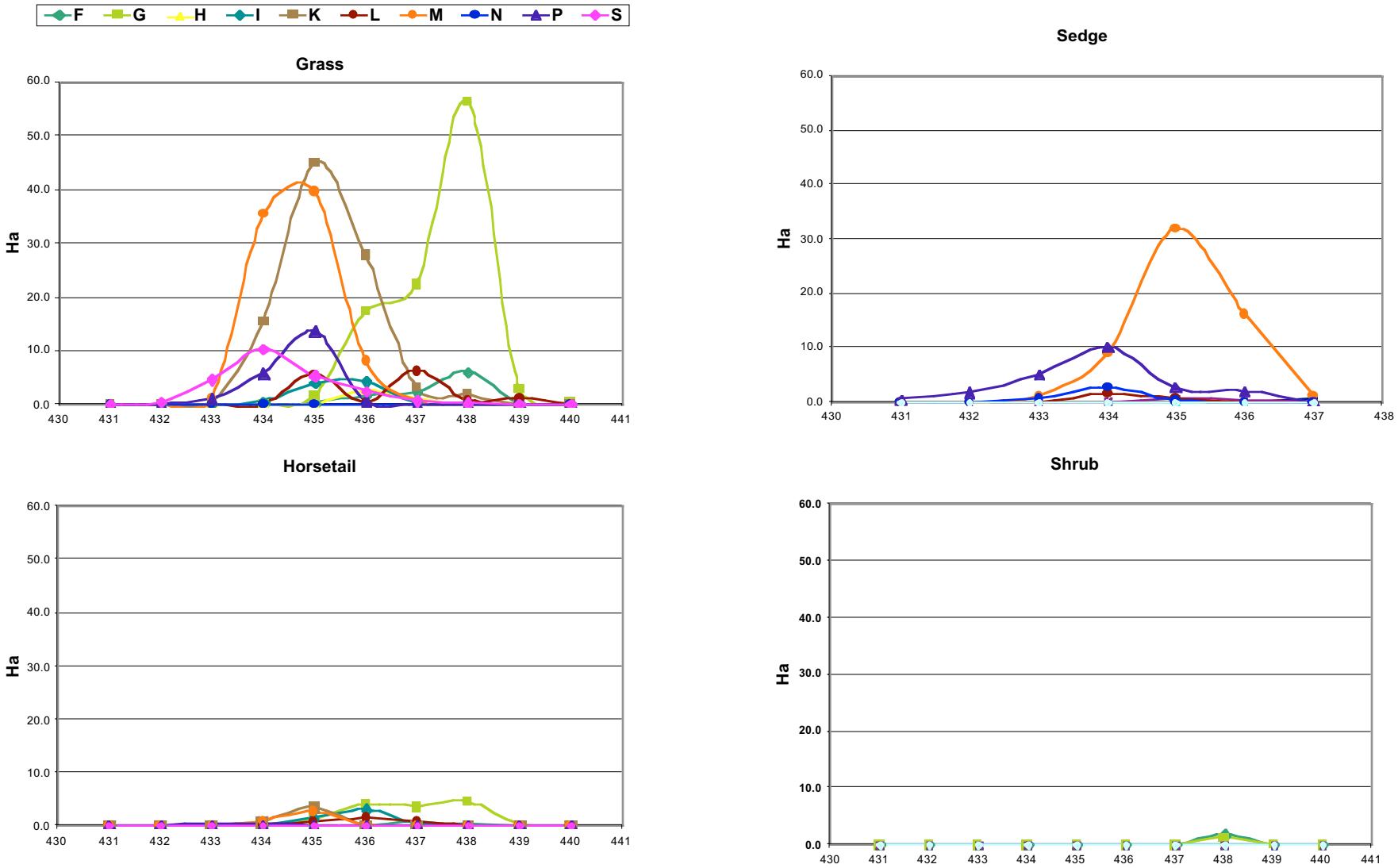
Incipient vegetation, the leading edge of newly forming perennial vegetation within the reservoir, is distributed primarily between 433 and 435m in elevation for the sedge and grass groups, and between 435 and 437 for horsetails (Figure 2). The grass group is the most narrowly focused, with most of the vegetation colonization occurring at 434m as of the year 2000. Depending on the hydrologic patterns, the developing vegetation may show different responses over time.

Figure 2: Distribution of Incipient Vegetation According to Elevation



The documentation of species distributions in relation to elevation is complicated by geographic location in the reservoir (Figure 3) In general, there is a tendency for the vegetation groupings to be shifted to lower elevations at further downstream locations. Horsetails occur primarily between 434 and 439m; at Area “G” they are mainly found between 435 and 439m whereas at Area “S” they occur between 434 and 435m. The grass dominated group is distributed over an elevation range of 433m and 439m. However, at any particular geographic site, the distribution is narrower, extending from 436 to 439 at Area “G”, 434 to 437 at Area “K”, and 433 to 436m at Area “S”. The sedge dominated group shows a similar pattern with its greatest abundance at Area “M” occurring primarily between 434 and 436m but between 433 and 435 at Area ”P”. The shrub communities are limited to Areas “F and “G”, both occurring at primarily 438m.

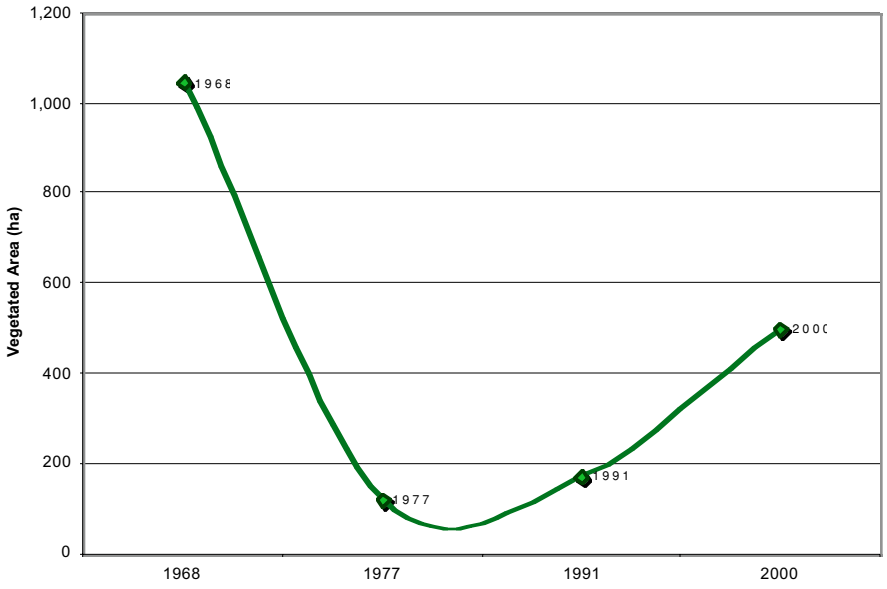
Figure 3: Vegetation Distribution According to Dominant Vegetation Type, Elevation and Geographic Area



3.3 Trends

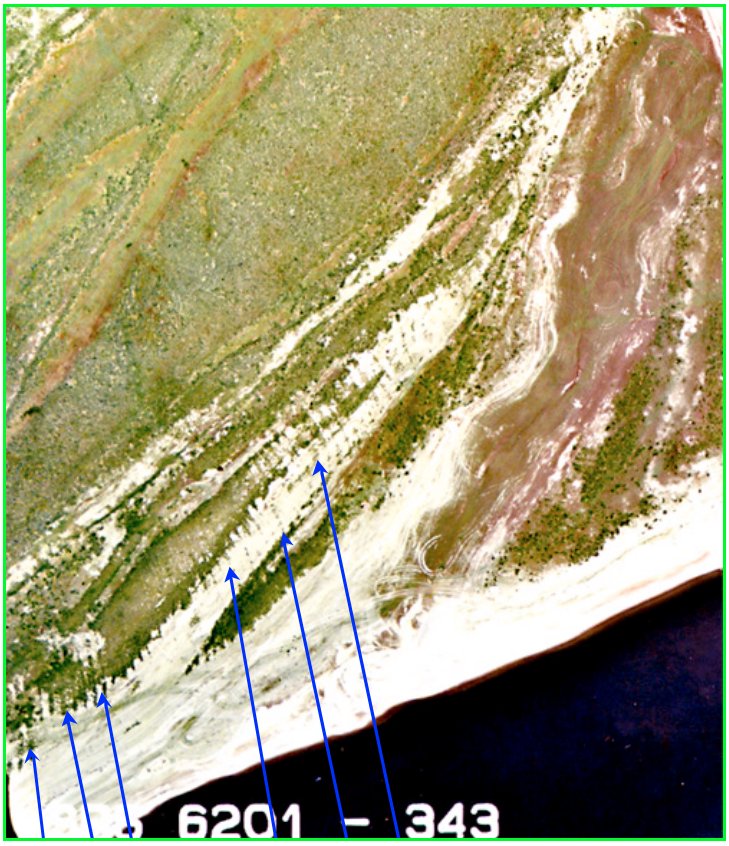
As a result of the limitations of the 1991 and 1996 photography, the analysis of species-specific trends was not possible in this project. However, overall, the vegetation cover (ha) since 1968 in the study area shows a dramatic 89% decline from 1968 to 1977, relatively little change (42%) from 1977 to 1991, followed by an almost 200% increase in the following 9 years (Figure 4). Vegetation losses from 1968 to 1977 were comprised primarily of vegetation found within the agronomic and timber harvested lands. Pre-impoundment vegetation occurred on benches removed from the river effect except during extreme flood years.

Figure 4: Total Vegetated Area Within Dust Control Treatment Areas Revelstoke Reach, Upper Arrow Reservoir



Although some vegetation recovery was noted between 1977 and 1991, it is highly unlikely that the 329 ha increase in vegetation cover between 1991 and 2000, could be attributed to natural colonization alone. Vegetation expansion has probably occurred due to a combination of factors such as recent reservoir operations, adaptation of native species to water level fluctuations and enhancement of native plant colonization by fall rye planting and fertilization. Specific data are not available to document the effects of the fall rye seeding program on vegetation expansion. However, indirect evidence is available on the ground and on a broader scale in the aerial photographs which show development of native vegetation in linear patterns which can only have evolved as a consequence of the fall rye seeding operations. On a large scale, the most dramatic example occurs in an image from Area “P”, where the linear patterns match tractor-tire spacing in this sandy substrate (Figure 5). This development of vegetation in a linear pattern is probably related to the incorporation of sedge seed into the substrate by tractor and seed-drill activity. The inclusion of fertilizer into the substrate at the time of fall rye seeding is also beneficial to sedge development. Ultimately the microclimatic changes created by fall rye cover, surface topography and the presence of organic material in the soil have all contributed to encouraging sedge establishment.

Figure 5: Linear Vegetation Establishment Patterns at Area"P".



Linear development of sedges

The absolute presence or absence of vegetation does not fully explain vegetation development in the draw down zone. Although an overall sparseness of vegetation was apparent in the 1977 and 1991 photos, it was not feasible to classify these areas according to density. For the year 2000 images, vegetation was classified according to the dominant vegetation type and density. These density categories offer an understanding of current vegetation development and future trends. In particular, the incipient and low density categories provide an understanding of the evolving vegetation patterns with the sparse, patchy development characteristic of these categories being followed by infilling and a development of denser vegetation categories.

Three major vegetation groupings account for most of the current vegetation distribution within the treatment areas. These include the communities dominated by grasses, sedges and horsetail (Table 5). The grass group dominates 75% of the mapped areas, followed by sedge (19%) and horsetail (6%). The grass group occurs at all densities but is dominated by the High and Medium density categories. Sedges are distributed relatively evenly between the Medium, Low and Incipient categories whereas horsetails are weighted toward the Medium category (Table 5).

Table 5: Distribution of Vegetation (ha) According to Dominant Cover and Density

Density / Dominant Sp.	H	M	L	I	Total
Grass	120.1	126.4	64.0	50.8	**361.3**
Sedge	0.4	27.7	27.0	36.6	**91.8**
Horsetail	3.0	15.3	9.6	2.3	**30.3**
Total	**123.6**	**169.5**	**100.6**	**89.8**	**483.4**

4.0 Summary and Recommendations

Mapping, using Year 2000 air photos of the vegetation distributions in the Revelstoke Reach draw down zone, has yielded valuable information concerning the presence, and density of plant species in the treatment areas. The information derived from this mapping will serve as an essential component of the reservoir productivity models presently under development for BC Hydro. The following comments and recommendations are based on the lessons learned from this program, supplemented with some additional insights from the companion vegetation program studies which this mapping exercise supports.

- There is a need to define clear objectives for future vegetation mapping studies.
- Aerial photographs are an essential tool for planning and undertaking vegetation assessments, particularly in dynamic environments. Appropriate historical aerial photography is a valuable tool for assessing long-term trends in vegetation patterns.
- Colour, 1:5,000 aerial photographs taken during the growing season are an important tool for large-scale vegetation mapping. In order to assess changes in vegetation cover and trends, photography should be repeated every 5 years. Photography should be undertaken prior to inundation but as late as possible in the growing season to allow for maximum plant development. At Upper Arrow Reservoir this would normally be late-May, early-June.
- The orthophotos generated as part of the Arrow program provided an essential tool for georeferencing the air photos and as a base for the vegetation maps.
- Vegetation maps should be prepared prior to the design and implementation of field vegetation programs as they are a valuable planning tool and an important part of sampling design.
- Digital mapping needs and formats should be identified and coordinated at the start of the project. All of the required materials (photos, orthophotos, digital base maps) need to be scheduled and coordinated to be available when necessary to the project. Stereo photo pairs should be from the same processing batch to ensure colour fidelity.
- Continued vegetation mapping on a 5 year interval is recommended to monitor developing vegetation patterns within Revelstoke Reach. This technique could be easily applied to other reservoirs to observe pre and post impoundment vegetation establishment and to assess the potential for vegetation enhancement.
- Vegetation mapping should be extended to cover the remainder of the Upper Arrow draw down zone wetlands (in addition to the previously mapped treatment areas) in order to obtain a complete record of the vegetated area within Revelstoke Reach.

5.0 Literature Cited

Carr, W.W., A.E. Brotherston, and A.I. Moody. 1993. Upper Arrow Dust Control Program, Revegetation and Special Studies: Program Summary and Recommendations 1990-1993. BC Hydro Contract Report.

AIM Ecological Consultants Ltd. and CARR Environmental Consultants. 2000. Quantification of Vegetation Inputs to Revelstoke Reach, Summary of 1999 Field Program – Vegetation and Soil Analyses. BC Hydro Contract Report.

CARR Environmental Consultants and AIM Ecological Consultants Ltd. 2002a. Quantification of Vegetation Inputs to Revelstoke Reach, Summary of 2000 Field Program – Vegetation and Soil Analyses. BC Hydro Contract Report.

CARR Environmental Consultants and AIM Ecological Consultants Ltd. 2002b. Synthesis of Vegetation and Soil Studies for Revelstoke Reach - Upper Arrow Reservoir. BC Hydro Contract Report.

Moody, A.I. 2002. Long-term Monitoring of Vegetation Expansion and Trials in the Dust Control Treatment Areas of Revelstoke Reach – Upper Arrow Reservoir. AIM Ecological Consultants Ltd.

6.0 Appendices

Appendix 1: News Releases - BC Hydro Dust Control Program - BC Hydro Website

Annual Program

* BC Hydro's dust control program in the upper Arrow Lakes Reservoir was established in June of 1990. The objective was to alleviate concerns in Revelstoke about air quality after several dust storms impacted the community.
* Reservoir draw down is an annual cycle, which typically lasts from December to June, with water levels at their lowest in the spring before snow melt. Exposed shorelines that do not support natural vegetation may be subject to dust storms during windy conditions.
* Snowpack and precipitation determine the size of the exposed area subject to wind erosion. Weather patterns are the key variable when it comes to the potential for wind erosion each year.
* Through the annual seeding of problem areas in the draw down zone with fall rye grass, the potential for dust storms has decreased significantly.
* The seed is planted in April and/or May with a mixture of 23 kilograms of seed and 45 kilograms of fertilizer per hectare.
* Local grasses (clover and reed) are also seeded with the fall rye in an attempt to establish natural vegetation. The fall rye provides a protective nursery crop, allowing local grasses to take root.
* After a number of years, it has been observed that the threat of wind erosion in seeded areas is reduced. Less seeding is required at higher elevations because the successive growth and decay of fall rye creates a seed bed, which helps start the next crop of grasses and other plants. Annual seeding of fall rye is required in the lower parts of the draw down zone where the extended period of flooding limits plant growth.
* Fall rye and other local plant species that have invaded the upper portions of the draw down zone provide food and cover for a variety of wildlife species, including insects, birds, small mammals deer and predators such as hawks and coyotes.
* On some sites, as natural vegetation is established, the seeding is modified to include the planting of willow cuttings to create natural barriers further protecting grasslands. These willow barriers create additional forage areas for wildlife.
* Fall rye also attracts insects, which, when the reservoir level rises and temporarily floods the grasslands, become food for fish.
* Recreational users enjoy horseback riding, cycling, hiking and bird watching in the revegetated areas south of Revelstoke. BC Hydro is undertaking studies in cooperation with The Friends of Mt. Revelstoke and Glacier, Parks Canada and the Canadian Wildlife Service to evaluate the ancillary benefits of revegetation (fish, wildlife and recreation) in the upper Arrow Lakes Reservoir, south of Revelstoke.

2001 Program

Due to low snowpack and reservoir levels this year, the Dust Control Program has been extended to other sections of the Arrow Lakes Reservoir and the Kinbasket Reservoir. While it is not an operational requirement of BC Hydro, the company is sensitive to the communities that would be affected by excessive dust. By proactively enhancing dust control efforts, BC Hydro will play a key role in reducing impacts resulting from unusual weather and reservoir conditions this year. BC Hydro continues to work toward identifying and minimizing impacts on the environment. Where impacts occur, we work to reduce them, enhance affected remaining habitat and sustain resources over the long term.

* This year BC Hydro is seeding approximately 640 hectares in exposed areas near the communities of Nakusp, Edgewood, Burton and Fauquier. 160 hectares will be planted near Valemount and 80 hectares will be seeded at Bush Arm. This is a one-time program being initiated to minimize impacts resulting from low snowpack and reservoir inflows being experienced across a western North America.
* Areas have been selected for fall rye seeding based on elevation (due to remain exposed for the rest of the year), substrate condition (particle size, tendency to contribute dust) gradient, and location (equipment access, near residential areas, in wind lanes to residential areas).
* The seed mix is mostly fall rye grain with the remainder comprised of several clover species and reed grasses.
* Seed drilling is the primary method of planting, but depending on soil conditions, aerial seeding is possible. * Planting will start in priority areas where substrate drying has started; this includes West Arrow Park and MacDonald Creek in the Arrow Lakes Reservoir and an area south of Valemount in the Kinbasket Reservoir. Once the seeding is complete, dust control measures will be enhanced with the planting of willow cuttings on some sites.

Appendix 2: Terms of Reference October 17, 2000

Mapping Component of the Study To Evaluate the Benefits of Reservoir

Shoreline Revegetation in Upper Arrow – Year 2

Goal

Quantify the distribution of vegetation and evaluate the colonization rates by native species.

Objective

Identify, map and quantify the distribution of different vegetation types within the study area based on current and historical aerial photos.

Study Area:

Previously revegetated areas referenced in previous reports in the Upper Arrow Reservoir. This includes the elevation band from 440m to 435m.

Scope of Work:

Key tasks for this study should include, but are not limited to the following:

1. Interpretation of the 2000 photos.
2. Overlay of 2000 vegetation data (species composition and distribution) onto the orthophoto base (2000 aerial photography.
3. Compare vegetation in new and historical aerial photographs. BCH has provided aerial photos from 1968 (B/W), 1985 (b/w) and 1991 (b/w). Stratify vegetation types (i.e. reed canary grass dominant or sedge dominant).

Deliverables:

1) Produce a hard copy map using the 2000 orthophoto as a base displaying the distribution of vegetation types in the study area based on the interpretation of air photos from 1968 to 2000. Color coding for different vegetation types and map scale must be approved by BC Hydro
2) Provide maps from previous years' photo interpretation of vegetation distribution.
3) Provide recommendations for future vegetation mapping to continue documenting historical changes in the draw down zone.
4) Produce a data report that contains the following:

    a) Methodology for vegetation distribution and area analysis.
    b) Area calculations of each delineated or stratified vegetation type for the current (year 2000) and previous years' vegetation distribution. Also summarize the rates of change over time by species for each treatment area.
    c) Summary of elevation limits according to species within the draw down zone.

Appendix 3: Mapping Notes

1968

SHEET 4

Area "F"

The northern part appeared to be dominated by relatively uniform herbaceous floodplain vegetation (probably E.f). A stand of coniferous trees (probably cedar) was situated on the southern portion of the main segment of "F". A section of bare substrate was obvious at low elevations. A narrow segment of wetland was present along the steep western shore at the most southern portion of "F".

Area "G"

The northern section had a mill and lumber storage along the shore. The remainder consisted of blocks of cleared agricultural meadow and treed blocks. Many slash piles were present along the river, indicating recent logging. Most of the treed area was fairly open with primarily deciduous (cottonwood?) forest. Old stream channels are apparent. The island at the north end showed some herbaceous vegetation along with shrubs and some trees at the southernmost limit.

Area "H"

This river bar was totally unvegetated but showed evidence of log piles used as buttressing to prevent erosion.

SHEET 5

Area "G"

Almost all of this area has been cleared and bulldozed.

Area "I"

All areas consisted of floodplain vegetation.

Area "K"

This area is predominantly agricultural with some remaining pockets of trees.

SHEET 6

Area "K"

About half of this area has been cleared and bulldozed, the remainder is treed. A relatively large depressional wetland (marsh) is situated on either side of the rail line, north of the cross road. The probable species complement is cattail, bulrush and sedge with some open water. The river bars appear to support some shrub and herbaceous floodplain vegetation growth.

Area "L 1"

All areas consist of floodplain vegetation.

SHEET 7

Area "L 1"

All areas consist of floodplain vegetation.

Area "L 2"

This area has been recently cleared, stumps are evident. A wetland is present at the base of the slope as is some open water.

Area "M1"

The island area consists of floodplain vegetation (presumably Equisetum, sedge and grass. The mainland area, adjacent to the rail line consists of primarily improved pasture and some unimproved pasture with a few patches of trees.

SHEET 8

Area "M"

This area is primarily agricultural with much of it consisting of rough pasture. Patches of sand are evident in places. Small patches of tress occur along the eastern shore and floodplain vegetation is present along the lower banks adjacent to the river.

SHEET 8/9

Area "N"

This area shows historical timber harvesting and recovery of the floodplain to a shrub state. No agricultural development is apparent.

Area "P"

The dust control area extends around the perimeter of area "P" and encompasses pasture, wetland, treed and logged areas. The wetland is an old oxbow with open water and probably sedge cover around the perimeter,

SHEET 10

Area "P"

This area is a relatively even mix of agricultural pasture and pockets of trees. Floodplain vegetation is present along the southern portion of the mainland as well ad an adjacent river bar.

Area "S"

Vegetation in this area ranges from developed agricultural at the northern end, natural vegetation along an elevation gradient at the central portion of the area. The natural vegetation is used as pasture at its higher extent and floodplain vegetation occurs at the lower extent. Freshwater input occurs along the slope and high energy flows are evident from the braided gravelly stream channels at the southern limit of the site.

Area "T"

All river bars in this area contain floodplain vegetation.

1977

SHEET 4

Area "F"

Most of the vegetation had disappeared including a wetland at the south end of the area. A very sparse band of *Equisetum* (?) occurred in the central area.

Area "G"

Most of the vegetation present, probably mostly horsetail and scouring rush, was concentrated along the rail line and along the more southern section.

Area "H"

No vegetation present.

SHEET 5

Area "G"

The southern portion of "G" (all of sheet 5) has a considerable extent of sparse vegetation, notably Eh and Ef..

Area "I"

Almost all barren except for a narrow strip of old wetland along the reservoir bank.

Area "K"

Much of northern "K" appears to be quite sandy. Patches of sedge occur along the margins of "dune"-like areas. Large patches of sparse Ef occur in the wet areas (depressions).

SHEET 6

Area "K"

Patchy vegetation is present in several locations, especially around the perimeters of the historic wetland and along the rail line

Area "L1"

This area is completely bare.

SHEET 7

Area "L1"

This area is completely bare.

Area "L2"

Vegetation is limited to the previously existing wetland area and higher elevation sites at the north and south of the area.

Area "M1"

Extensive but sparse vegetation growth is present close to the rail line at the northern tip of this site. The island has a few sparse patches of vegetation.

SHEET 8

Area "M1"

Sparse patches of vegetation are distributed close to the shorelines and close to the channels.

Area "N"

No vegetation is evident.

SHEET 9

Area "P"

Small, very sparse patches of vegetation in several locations.

SHEET 10

Area "P"

Very little, sparse vegetation occurs in 4 locations.

Area "S"

Sparse patches of vegetation in several locations.

Area "T"

No vegetation present.

1991

SHEET 4

Area "F"

This area has been recolonized by abundant vegetation in all areas.

Area "G"

Sparse vegetation is developing on the island and vegetation along the rail line is starting to expand westward.

Area "H"

Shows no vegetation development.

SHEET 5

Area "G"

Much of the area is sparsely vegetated.

Area "I"
The northern tip is sparsely vegetated, but the southern portions are almost bare.
Area "K"
Patchy vegetation has expanded in the northern portions.

SHEET 6

Area "K"
Patchy vegetation is present in several locations, but has disappeared around the perimeters of the historic wetland. A very sparse incipient patch has appeared on the extreme western river bar.
Area "L1"
A small, sparse patch of vegetation is present on the river bar.

SHEET 7

Area "L1"
One small patch of vegetation is present along the main shore.
Area "L2"
Vegetation is limited to the higher elevation sites at the north of the area and a few small patches along the main channel.
Area "M1"
Limited, sparse growth close to the rail line. The island is devoid of vegetation.

SHEET 8

Area "M1"
Very sparse patches of vegetation occur in the central portion of the area. Numerous sandy patches surrounded by horsetail are apparent.
Area "N"
No vegetation is evident.

SHEET 9

Area "P"
Small, very sparse patches of vegetation in a few locations.

SHEET 10

Area "P"
Vegetation has expanded slightly since 1977, much of this is horsetail.
Area "S"
Sparse patches of vegetation in several locations.
Area "T"
No vegetation present.

2000

SHEET 4

Area "F"
This area is almost completely vegetated and shows relatively dense shrub development at the northern end (at elevations above 437).
Area "G"
The bulk of area "G" is densely vegetated by primarily reed canary grass except for the seed trial area and sections where Equisetum (both species) is abundant. Horsetails have become less prevalent over time as reed canary grass has expanded but they still retain dominance in low spots which have standing water.
The island has patchy, incipient vegetation but appears to have undergone sand deposition and burial of establishing vegetation.
Area "H"

SHEET 5

Area "G"
Much of the area is densely vegetated with Pa mix. Cl seems to be concentrated along the shoreline.
Area "I"
Well developed vegetation (M) along eastern sections of Area I (south). Sand-bar to north has several pockets of developing vegetation. Deposition may be a problem in some areas.
Area "K"
Much of the area is densely vegetated with Pa mix. Ef and Smartweed are present in depressions. Bare sandy patches are still present with Cl concentrated around the perimeter.

SHEET 6

Area "K"
Mainland part of area is completely vegetated with predominantly moderate to high density reed canary grass dominated vegetation. River bars have low to moderate growth of a reed canary grass and sedge mix with additional areas of incipient growth extending form the more heavily developed vegetation stands.
Area "L1"

Small patches of vegetation have developed into low density. No evidence of additional incipient growth. High density stand of reed canary grass mix at extreme southern extent.

SHEET 7

Area "L1"

This area has a solid growth of primarily reed canary grass mix throughout the mainland portion. The presence of stream flow may contribute to plant growth..

Area "L2"

This area has a solid growth of primarily reed canary grass mix throughout the mainland portion

Area "M1"

Extensive, high density vegetation the northern end of this site, lower densities and incipient vegetation to the south. The main M1 island has low density reed canary grass and sedge at the northern end and incipient vegetation throughout much of the remainder. Several areas of incipient sedge and reed canary grass show linear patterns of growth. Some areas which were drill seeded in 2000 showed enhanced greening of permanent vegetation above what would be expected from the additional coverage of the fall rye. This may show a fertilizer response.

SHEET 8

Area "M1"

Low to moderate density vegetation is distributed throughout the eastern portion of the area. Numerous sandy and coarse textured substrate areas indicate a high energy environment..

Area "N"

Incipient sedge and reed canary grass is present along the north-west portion of this area..

SHEET 9

Area "P"

Most of the western island is occupied by incipient sedge. The mainland has low to moderate densities of reed canary grass and sedge throughout.

SHEET 10

Area "P"

The mainland has low to moderate densities of reed canary grass and sedge throughout. Several areas of incipient sedge and reed canary grass show linear patterns of growth.

Area "S"

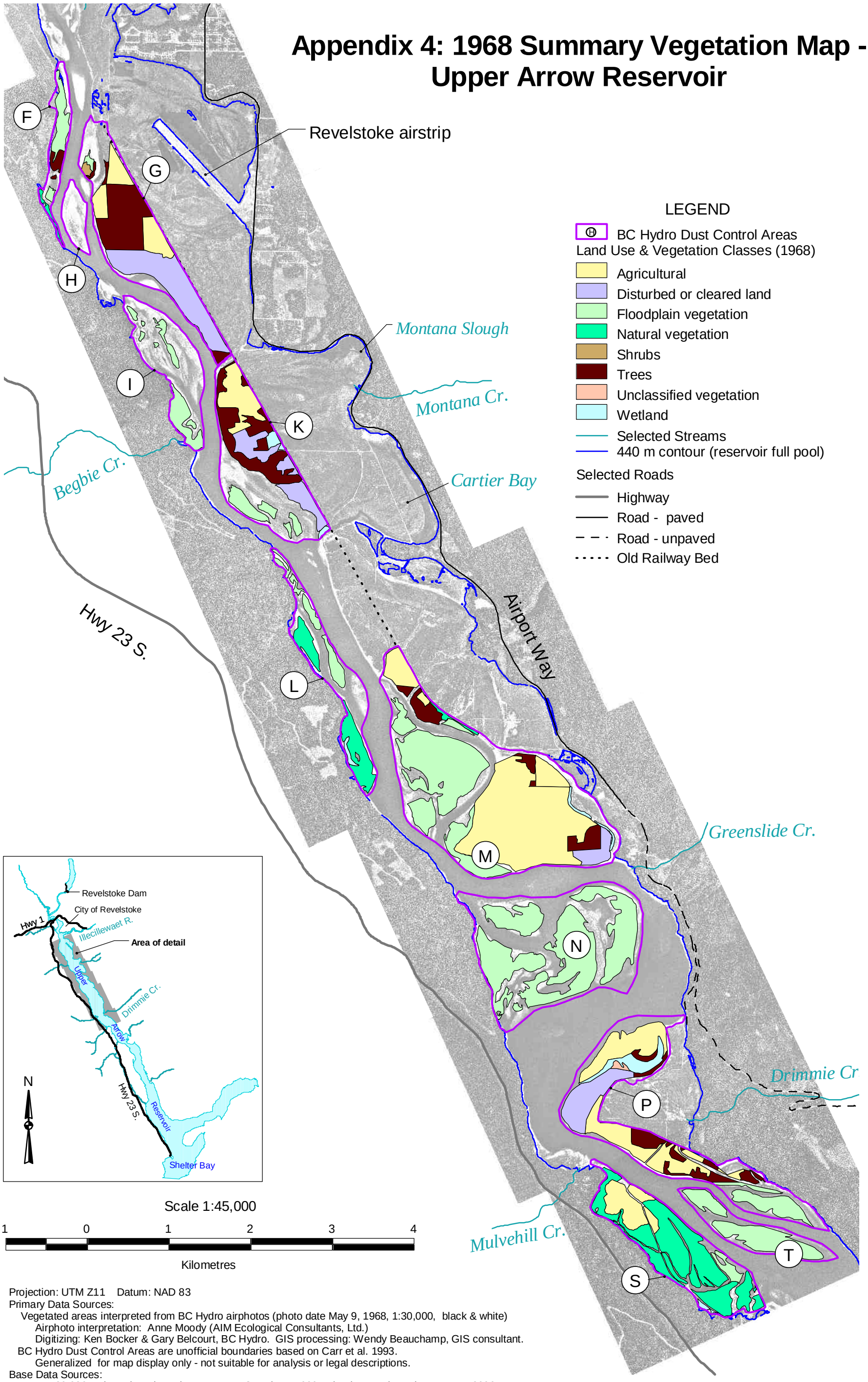
Several areas of vegetation extending from the highest elevations (high density) to lower elevations (low density and incipient). Creek fan vegetation at south end is labeled unclassified because field verification has not been done.

Area "T"

No vegetation present.

Appendix 4: 1968 Summary Map

Appendix 4: 1968 Summary Vegetation Map - Upper Arrow Reservoir



Projection: UTM Z11 Datum: NAD 83

Primary Data Sources:

Vegetated areas interpreted from BC Hydro airphotos (photo date May 9, 1968, 1:30,000, black & white)
Airphoto interpretation: Anne Moody (AIM Ecological Consultants, Ltd.)
Digitizing: Ken Bocker & Gary Belcourt, BC Hydro. GIS processing: Wendy Beauchamp, GIS consultant.

BC Hydro Dust Control Areas are unofficial boundaries based on Carr et al. 1993.
Generalized for map display only - not suitable for analysis or legal descriptions.

Base Data Sources:

TRIM 1:20,000, selected roads and streams. BC Hydro 1:5000 orthophotos: photo date June 4, 2000
Contours from BC Hydro 10m DEM: May 24, 2000

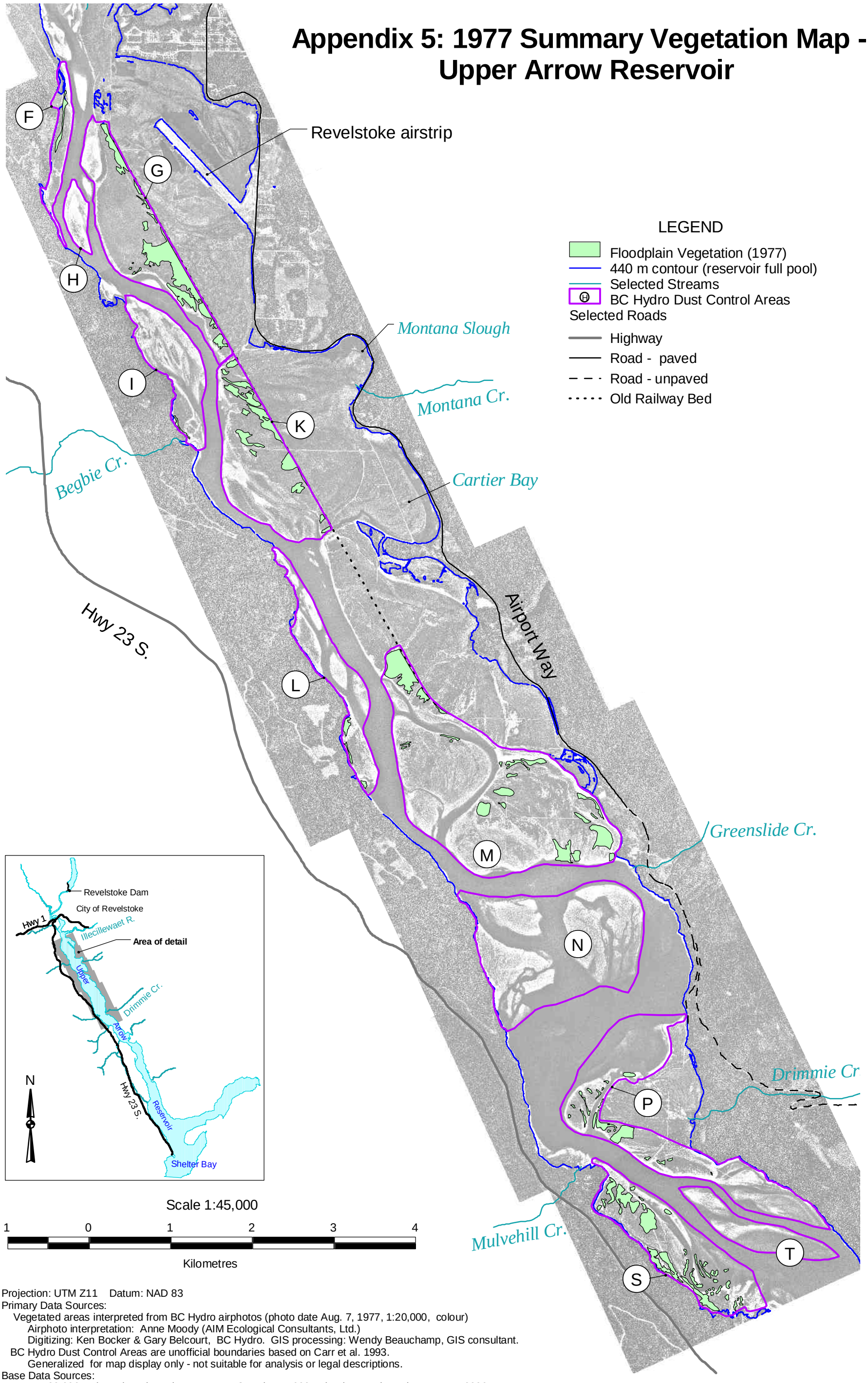
Map Production: Wendy Beauchamp, Consultant. Map produced for AIM Ecological Consultants Ltd. and BC Hydro.

Map Production Date: April 2002, modified June 2002 v1.3 Software: ArcView 3.2

BC hydro

Appendix 5: 1977 Summary Map

Appendix 5: 1977 Summary Vegetation Map - Upper Arrow Reservoir

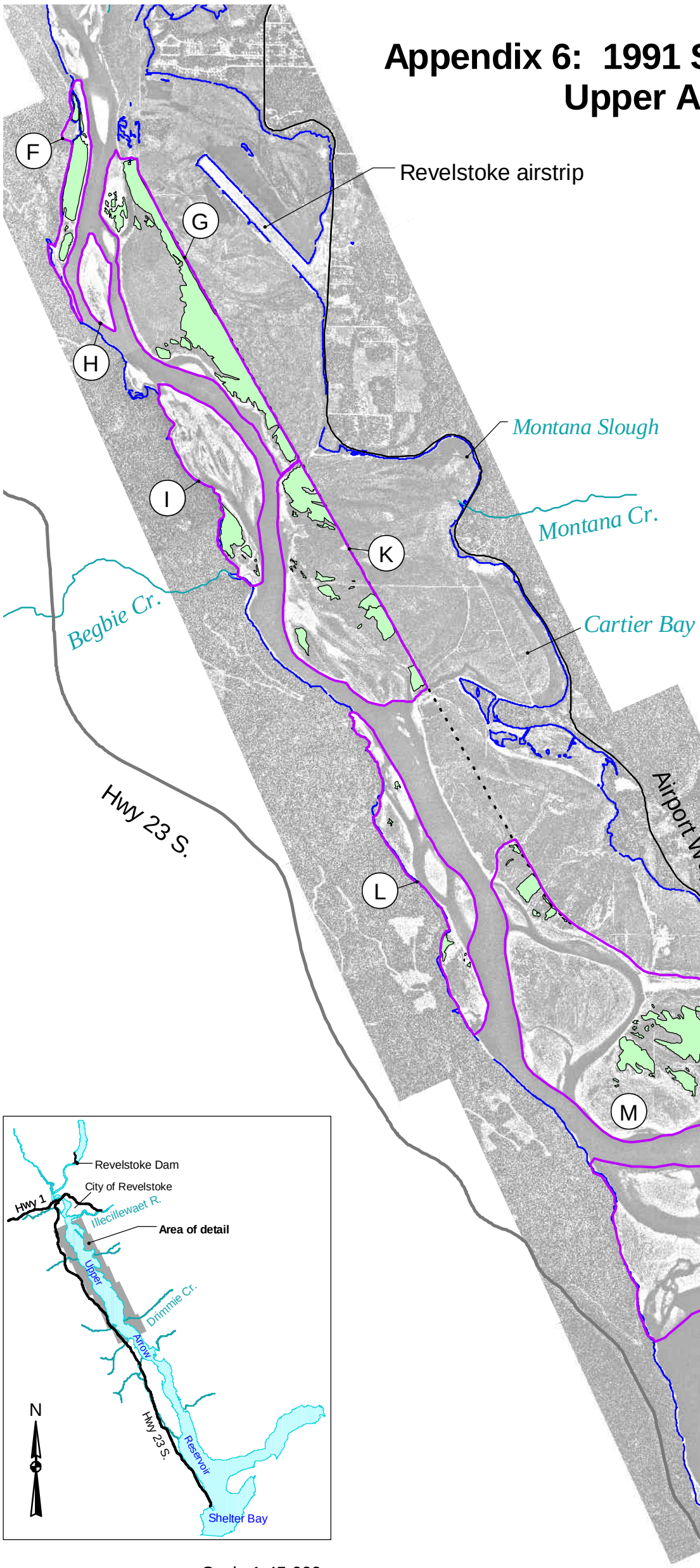


Projection: UTM Z11 Datum: NAD 83
Primary Data Sources:
Vegetated areas interpreted from BC Hydro airphotos (photo date Aug. 7, 1977, 1:20,000, colour)
Airphoto interpretation: Anne Moody (AIM Ecological Consultants, Ltd.)
Digitizing: Ken Bocker & Gary Belcourt, BC Hydro. GIS processing: Wendy Beauchamp, GIS consultant.
BC Hydro Dust Control Areas are unofficial boundaries based on Carr et al. 1993.
Generalized for map display only - not suitable for analysis or legal descriptions.
Base Data Sources:
TRIM 1:20,000, selected roads and streams. BC Hydro 1:5000 orthophotos: photo date June 4, 2000
Contours from BC Hydro 10m DEM: May 24, 2000
Map Production: Wendy Beauchamp, Consultant. Map produced for AIM Ecological Consultants Ltd. and BC Hydro.
Map Production Date: April 2002 v1.3, modifiied June 2002 Software: ArcView 3.2

BC hydro

Appendix 6: 1991 Summary Map

Appendix 6: 1991 Summary Vegetation Map
Upper Arrow Reservoir



LEGEND

- Floodplain Vegetation (1991)
- 440 m contour (reservoir full pool)
- Selected Streams
- Ⓗ BC Hydro Dust Control Areas

Selected Roads

- Highway
- Road - paved
- Road - unpaved
- Old Railway Bed

Scale 1:45,000

1 0 1 2 3 4

Kilometres

Projection: UTM Z11 Datum: NAD 83

Primary Data Sources:

Vegetated areas interpreted from BC Hydro airphotos (photo date Apr. 12, 1991, 1:10,000, black & white)
Airphoto interpretation: Anne Moody (AIM Ecological Consultants, Ltd.)
Digitizing: Ken Bocker & Gary Belcourt, BC Hydro. GIS processing: Wendy Beauchamp, GIS consultant.
BC Hydro Dust Control Areas are unofficial boundaries based on Carr et al. 1993.
Generalized for map display only - not suitable for analysis or legal descriptions.

Base Data Sources:

TRIM 1:20,000, selected roads and streams. BC Hydro 1:5000 orthophotos: photo date June 4, 2000
Contours from BC Hydro 10m DEM: May 24, 2000

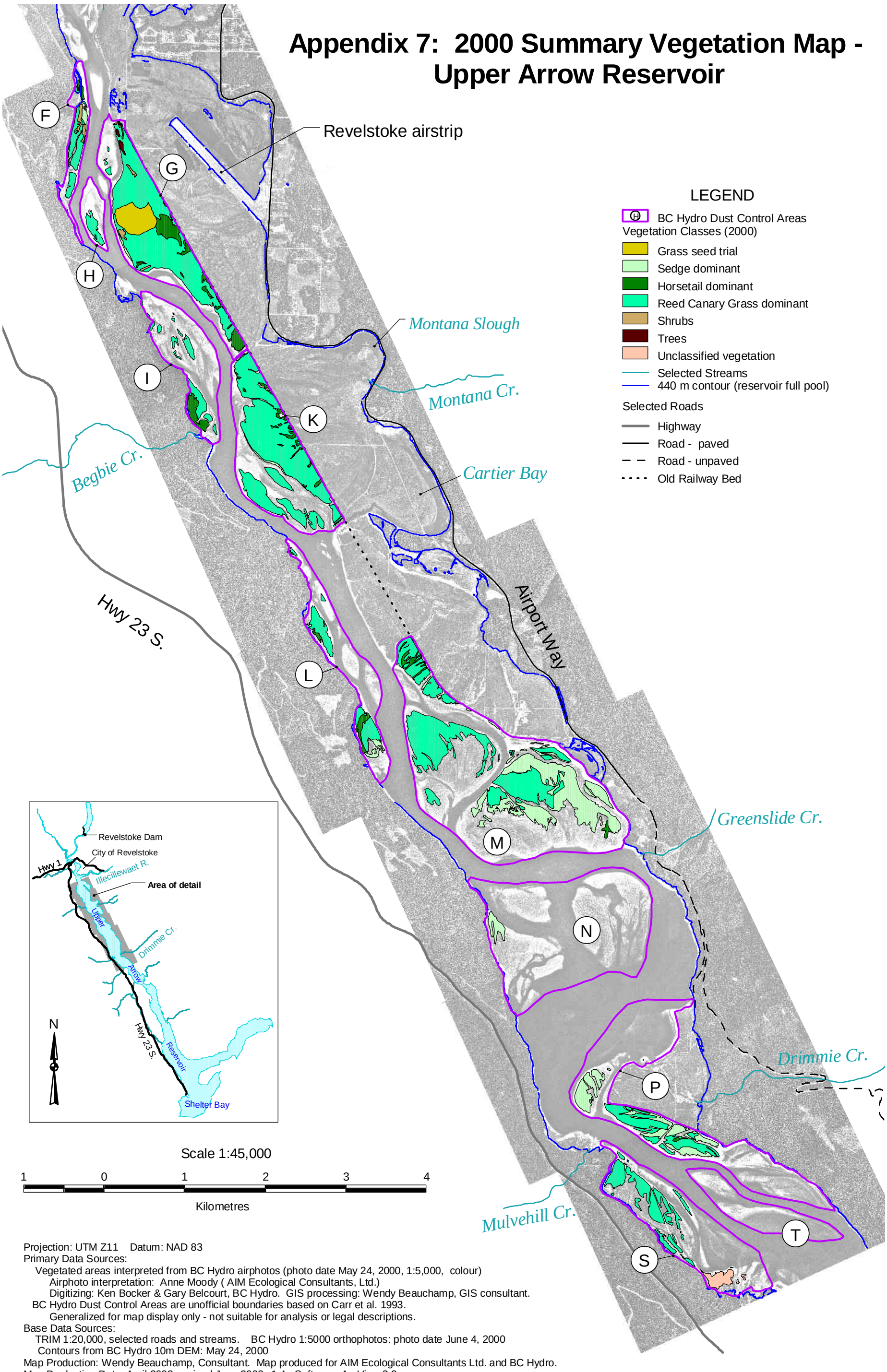
Map Production: Wendy Beauchamp, Consultant. Map produced for AIM Ecological Consultants Ltd. and BC Hydro.

Map Production Date: April 2002 v1.2, revised June 2002 Software: ArcView 3.2

BC hydro

Appendix 7: 2000 Summary Map

Appendix 7: 2000 Summary Vegetation Map - Upper Arrow Reservoir



Projection: UTM Z11 Datum: NAD 83
Primary Data Sources:
Vegetated areas interpreted from BC Hydro airphotos (photo date May 24, 2000, 1:5,000, colour)
Airphoto interpretation: Anne Moody (AIM Ecological Consultants, Ltd.)
Digitizing: Ken Bocker & Gary Belcourt, BC Hydro. GIS processing: Wendy Beauchamp, GIS consultant.
BC Hydro Dust Control Areas are unofficial boundaries based on Carr et al. 1993.
Generalized for map display only - not suitable for analysis or legal descriptions.
Base Data Sources:
TRIM 1:20,000, selected roads and streams. BC Hydro 1:5000 orthophotos: photo date June 4, 2000
Contours from BC Hydro 10m DEM: May 24, 2000
Map Production: Wendy Beauchamp, Consultant. Map produced for AIM Ecological Consultants Ltd. and BC Hydro.
Map Production Date: April 2002, revised June 2002 v1.4 Software: ArcView 3.2

BC hydro

Appendix 8: GIS Summary – Area (m^2) of Dominant Vegetation Type by Dust Control Area and Elevation

DUST AREA	ELEVATION (Upper limit)	Grass	Horsetail	Sedge	Shrub	Tree	Unclas. Veg.	Wetland	Grand Total
F	435	983		59					1,042
	436	16,020	503	509	49				17,081
	437	23,822	4,750	5,997	324				34,894
	438	59,470	2,019	9,162	17,907				88,558
	439	1,360	315	367	223				2,265
	440	5	39	45					89
F Total		**101,661**	**7,626**	**16,139**	**18,503**				**143,929**
G	433	28							28
	434	105		8					113
	435	14,616	10,736	250					25,602
	436	173,411	40,148	2,066					215,624
	437	221,550	34,907	2,481	103	189			259,231
	438	564,376	44,339	3,742	13,847	3,286			629,589
	439	28,138	2,118		2,466	4,504			37,226
	440	973	11		119	147			1,249
	441	41				232			273
G Total		**1,003,236**	**132,258**	**8,547**	**16,536**	**8,359**			**1,168,935**
H	435	1,192							1,192
	436	26,861							26,861
	437	10,251							10,251
H Total		**38,304**							**38,304**
I	433	154	6						160
	434	5,433	558						5,991
	435	38,102	13,952						52,054
	436	42,997	29,401						72,398
	437	4,225	2,817						7,041
	438	530	310						840
	439	160							160
	440	132							132
	441	106							106
	442	40							40
	443	10							10
	444	2							2
I Total		**91,892**	**47,043**						**138,935**
K	432	122							122
	433	4,464	33	712					5,209
	434	152,775	6,299	2,155					161,230
	435	449,138	33,313	6,306					488,757
	436	277,990	880	5,490					284,360
	437	32,075		115					32,190
	438	17,180							17,180
	439	23							23
K Total		**933,767**	**40,526**	**14,777**					**989,070**

DUST AREA	ELEVATION (Upper limit)	Grass	Horsetail	Sedge	Shrub	Tree	Unclas. Veg.	Wetland	Grand Total
L	433	45		101					146
	434	407	1,519	14,405					16,331
	435	56,186	7,991	6,452					70,630
	436	4,216	13,623						17,839
	437	62,012	9,352						71,363
	438	7,897	493						8,390
	439	11,464	21						11,485
	440	145	2						147
	443	2,047							2,047
L Total		**144,420**	**33,000**	**20,959**					**198,379**
M	432	88		248					336
	433	11,875	57	12,101					24,032
	434	354,201	8,859	90,614					453,674
	435	396,830	27,153	320,025					744,007
	436	81,343	2,480	162,240					246,063
	437	5,451		12,703					18,153
	438			191					191
	439			1,341					1,341
M Total		**849,787**	**38,549**	**599,462**					**1,487,799**
N	432			691					691
	433			7,183					7,183
	434			25,939					25,939
	435			3,003					3,003
N Total				**36,816**					**36,816**
P	431			5,472					5,472
	432	22		17,647					17,669
	433	10,362	1,192	49,470					61,024
	434	58,430	1,997	102,453					162,880
	435	136,032	448	26,035					162,516
	436	6,447		20,590					27,037
	437			2					2
P Total		**211,293**	**3,637**	**221,667**					**436,598**
S	431	261							261
	432	2,782							2,782
	433	46,290					6		46,296
	434	101,761					258		102,018
	435	53,212					3,194		56,406
	436	25,293					14,821		40,114
	437	7,161					22,046	185	29,392
	438	2,278					14,064	764	17,105
	439	2					527	632	1,160
	440							202	202
	441							70	70
S Total		**239,039**					**54,914**	**1,851**	**295,805**
Grand Total (m^2)		**3,613,400**	**302,640**	**918,367**	**35,039**	**8,359**	**54,914**	**1,851**	**4,934,569**

Appendix 9: GIS Results – Arrow_veg_elev_00r.xls (on CDR)

Appendix 9

Table of Contents