CAPITAL ENGINEERING GROUP LTD

Municipal / Environmental / Land development

STORMWATER MANAGEMENT REPORT
CBC NATIONAL ALARM CENTRE
WAREHOUSE ADDITION
RICHARDSON SIDE ROAD
CARP, ONTARIO
June 8, 2020

EXISTING CONDITIONS

This property is located at the intersection of Richardson Side Road and William Mooney Drive, in the former Township of West Carleton within the metropolitan area of the City of Ottawa. The site is rectangular in shape with roughly 305 m frontage along Richardson Side and 590 m depth. The total site area is approximately 18 ha.

The property is zoned rural with an RU designation. It is currently developed and used by the CBC Corporation for film archive storage. The existing development includes two buildings connected with a link. The site has paved laneways along the frontage and sides of the existing buildings with access entries to both Richardson Side Road and William Mooney Drive. There is also an existing paved parking at the front plus gravel and paved storage areas around the buildings.

The existing buildings are serviced by onsite water supply well and sewage disposal systems.

Current site drainage is either in the easterly direction towards the Richardson Side Road roadside ditch, or northerly and southerly to existing swales. The swales outlet to a municipal drain running through the property. The drain is designated as Huntley Creek and flows in the northeasterly directions, eventually outletting to Carp River roughly 6 kilometers downstream of the site.

Overhead utilities are available along the adjacent municipal roads.

PROPOSED DEVELOPMENT

The previously approved site plan (2007) included a future building plus extension of the gravel storage area (phase 3). The current site plan application is submitted to proceed with the design and construction of phase 3.

The new building has a footprint of 1175 m^2 which is less than what was proposed in the approved site plan. The existing paved access roads and parking areas will not be altered. A portion of the gravel storage area shown on the original Grading and Drainage Plan has since been paved.

BUILDING SERVICES

Details of the existing water supply well and on-site sewage disposal system were addressed in the hydrogeological report submitted with the previous site plan application. The proposed phase 3 building will not include any plumbing fixtures.

FIRE FLOW

On site fire flow supply is provided by the existing underground storage tanks. The required storage volume took into account the proposed phase 3 building. It was calculated and approved as part of the previous site plan application.

POST DEVELOPMENT GRADING AND DRAINAGE

The post development grading and drainage design is indicated on the Grading and Drainage Plan prepared by Capital Engineering Group Ltd (Dwg. 19-41, G1).

STORMWATER MANAGEMENT

Criteria

The City of Ottawa and Mississippi Valley Conservation Authority require that post development runoff be subject to on-site stormwater management. We have pre-consulted with both agencies, and the following is an outline of the required criteria (see attached memos).

- Post development runoff to be controlled to pre-development levels, based on the previous (approved) Grading and Drainage Plan and Storm Servicing Brief.

- Enhanced level quality control (80 % SS removal) and thermal control.

  Due to the rural nature of this site (shallow open channel flow), mechanical quality control equipment such as water quality units are not practical to utilize.

  Preliminary discussions with MVCA indicated that the agency is willing to consider Best Management Practices (BMP's) for quality control and "best effort" approach to thermal control.

  BMP measures will include flat swales and vegetated filter strips. Thermal control will be accomplished by vegetation and a tree planting scheme to provide shading along the swales and other landscaped areas.

  On site infiltration will be maximized by directing runoff from impervious surfaces across the above noted BMP's, prior to discharging to the receiving water course.

Quantity Control

The drainage areas are delineated on the Drainage Areas Plan (Dwg 19-41, G2). The total area and overall drainage patterns match the original Grading and Drainage plan as well as the Storm Servicing Brief. As mentioned above, a portion of the gravel storage area north of the buildings has been paved. This results in a slight increase in the overall runoff coefficient for the site.

The following is a breakdown of the new drainage areas compared to the original Storm Servicing Brief.

	Proposed	Original (From Brief)
Buildings	2,180 m^2	2,419 m^2
Paved areas	5,750 m^2	2,774 m^2
Gravel areas	2,510 m^2	5,245 m^2
Landscaping	11,900 m^2	11,902 m^2
Total Area	22,340 m^2	22,340 m^2
Runoff coefficient	$C_5 = 0.51$	$C_5 = 0.49$
CA	11,384	10,988

Please note that the drainage areas used in the above noted calculations represents a fraction (12 %) of the total site area. The balance of the site remains in its natural undisturbed state.

The post development runoff coefficient is roughly four percent (4 %) higher than the predevelopment conditions. In our opinion, this increase is marginal and does not warrant implementing on site flow controls. The grading and drainage design promotes on site infiltration and minimizes the peak runoff by re-routing the flow through flat swales and vegetation strips, prior to outletting to the receiving water course.

Quality Control

Quality control of runoff from this site is achieved by Best Management Practices. Drainage from all hard surfaces are directed across vegetated filter strips and / or flat swales prior to discharging to Huntley Creek.

Vegetated Filter Strip

A properly designed vegetated filter strip will achieve the desired infiltration and suspended solids removal to meet the required criteria. The effectiveness of vegetated filter strips is reinforced by an experiment conducted by the Guelph Turfgrass Institute in collaboration with the Water Monitoring Section of the Ministry of Environment. The experiment uses Perennial Ryegrass with varying filter strip lengths (width of the grass) and a flow rate of between 0.25 l/s and 1.7 l/s per linear meter. The final report concluded that up to 95 % SS removal can be achieved within the first 5 meters of the filter strip. A copy of the report is appended for reference.

The existing grassed area along the western edge of the graveled storage area will act as a vegetated filter strip. The width of the vegetation ranges between 22 m and 36 m. The filter strip length (along the gravel edge) is approximately 90 m.

Drainage from the gravel area as well as a portion of phase 3 building and adjacent pavement is directed across this filter strip. The drainage area is broken down as follows

Building	400 m^2
Pavement	400 m^2
Gravel	1,760 m^2
Total	2,560 m^2

Combined C = 0.80 (0.96 for 100 year storm)

Post development runoff from this area is estimated as follows

$Q = 2.78$ CIA, where

Q is the flow rate in liters per second
C is the runoff coefficient
I is the rainfall intensity based on a concentration time of T = 20 minutes
A is the drainage area in hectare= 0.256 ha

$Q_2 = 2.78 \times 0.80 \times 52 \times 0.256 = 29.6$ l/s
$Q_5 = 2.78 \times 0.80 \times 70 \times 0.256 = 39.8$ l/s
$Q_{100} = 2.78 \times 0.96 \times 120 \times 0.256 = 82.0$ l/s

The calculated flow rates per meter along the length (90 m) of the filter strip range from 0.32 l/s for the 2 year peak flows to 0.9 l/s for the 100 year event. This falls within the same range used in the Guelph Turfgrass Institute experiment. The width of the filter strip (average of 29 m) is considerably more than the minimum of 5 m referenced in the experiment. Therefore, the enhanced level quality control criteria set by MVCA should be achieved during minor as well as major storm events.

In addition to sediment removal, the vegetated filter strip will act as an infiltration buffer before the runoff enters the receiving water course. The underlying soil condition on this site is classified as sandy loam. Table 3.1 of the MOE SWM Planning and Design Manual (attached) estimates that, for this type of soils under the urban lawn category, the runoff rate is limited to approximately 20 % of the annual precipitation. The balance of the water budget is taking up by a combination of infiltration and evapotranspiration.

Grassed Swales

As mentioned above, there are existing swales along the north and south edges of the drainage area. The drainage areas to each swale are broken down as follows:

South Swale

Buildings	800 m^2
Pavement	100 m^2
Gravel	860 m^2
Grass	2,740 m^2
Total	4,500 m^2

Runoff coefficient C = 0.44

$Q_5 = 2.78 \times 0.44 \times 70 \times 0.45 = 38.5$ l/s

North Swale

Buildings	790 m^2
Pavement	4,410 m^2
Grass	600 m^2
Total	5,800 m^2

Runoff coefficient C = 0.83

$Q_5 = 2.78 \times 0.83 \times 70 \times 0.58 = 93.7$ l/s

The peak flow depths and velocities in the swales can be estimated by applying Manning's formula to the swale cross sections.

$$Q = A \times R^{0.67} \times S^{0.5} / n$$

Where Q is the peak flow calculated above
A is the area of flow, varies with the depth of flow
S is the longitudinal slope
n is the roughness coefficient, n = 0.035.

The south swale has a bottom width of roughly 1.5 m, 4 to 1 side slopes and a longitudinal slope of 0.3 % (middle portion). The north swale has a bottom width of roughly 1.5 m, 5 to 1 side slopes and a longitudinal slope of 0.3 %.

The calculated depths of flow during the 5 year storm event are 0.07 m and 0.12 m and the velocities are 0.3 m/s and 0.4 m/s for the south and north swale respectively.

The swale cross sections and longitudinal slopes as well as the flow depths and velocities all conform to the recommendations in the MOE SWM Planning and Design Manual to provide effective water quality treatment.

Some infiltration and evapotranspiration will also occur in the swales due to the flat longitudinal slopes and low flow rates.

Thermal Control

Natural growth of the vegetation within the filter strip, coupled with infrequent cutting is expected to provide maximum shading and cooling.

The existing swales are lined with mature growth to provide shading and lower the temperature of the flow. Additional trees will also be planted where there are gaps along the length of the swales as well as Huntley Creek, to ensure continuous shading.

The drainage design described above will result in considerable infiltration during frequent storm events, thus minimizing the net runoff from the site.

EROSION AND SEDIMENT CONTROL

Erosion and sediment control measures will be put in place prior to construction and will remain until all landscaping work is completed. The measures will conform to MOE Guideline B-6, "Guidelines for Evaluating Construction Activities Impacting on Water Resources". Silt fences will also be erected along the outside limits of the construction area.

The measures are detailed on the Erosion & Sediment Control Plan (Dwg. 16-02, G3).

REVIEW BY OTHER AGENCIES

The engineering drawings and SWM report will be circulated to the Mississippi Valley Conservation Authority as part of the site plan application process.

SUMMARY / CONCLUSIONS

On-site stormwater management has been designed for the site in accordance with directions provided by the City of Ottawa Infrastructure Approvals Branch and the MVCA. The SWM measures are summarized as follows:

- Post development runoff is equivalent to predevelopment levels. The slight increase in the overall runoff coefficient is marginal and does not warrant implementing on site flow controls.

- Enhanced level quality control.

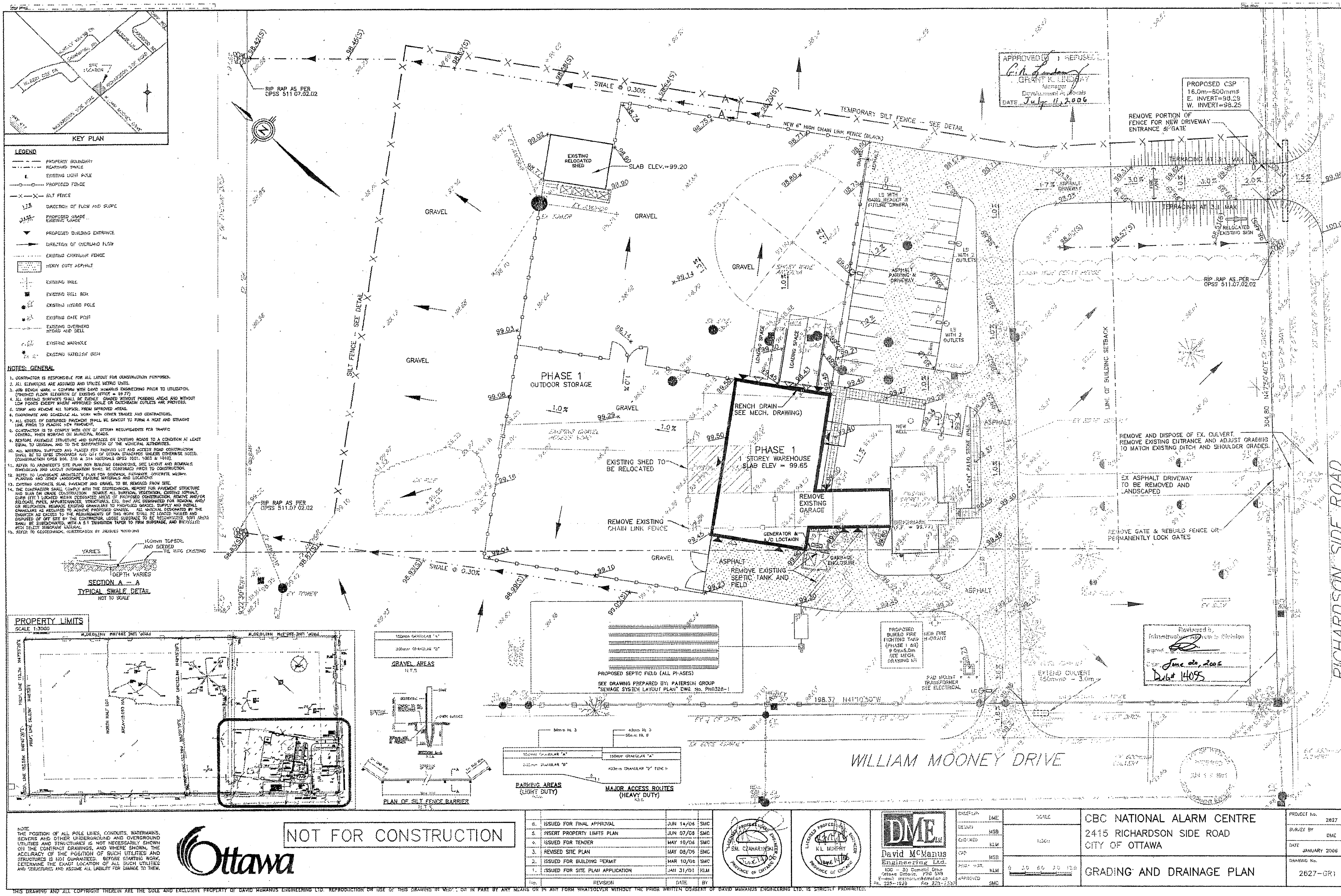
- Thermal control is achieved by planting trees and forestation beds along the drainage outlets to provide shading and cooling.

- On site infiltration is maximized by directing the runoff from impervious areas through vegetated filter strips and / or flat swales, before discharging to Huntley Creek.

Prepared by
Capital Engineering Group Ltd.

Andy Naoum, P.Eng.
Senior Consultant

LICENSED PROFESSIONAL ENGINEER
AMINE NAOUM
June 8/22
PROVINCE OF ONTARIO



A0018872_1-00001

Storm Servicing Brief
CBC National Alarm Centre

D.M.E. Project No. 2627

Prepared for:
David Mailing Architect Ltd.

Prepared by:

David McManus Engineering Ltd.

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400 – 30 Camelot Drive
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OK – June 12/06 NF.

January 31, 2006

Revision 1 – May 30, 2006

TABLE OF CONTENTS

APPENDIX

1. *INTRODUCTION*

The subject property consists of approximately 2.2 hectares of land and is located in the northeast corner of the intersection of Richardson Side Road and William Mooney Drive. (see Key Plan Figure 1.0 in Appendix A). This brief details the overall change in site stormwater characteristics resulting from the proposed expansion of the existing Canadian Broadcasting Corporation (CBC) National Alarm Centre facility.

2. *EXISTING CONDITIONS*

A two-storey administration building and two storage buildings currently occupy the site. Paved accesses and parking areas are present as well as some gravel areas at the base of satellite towers. The remainder of the site is grassed.

The site is generally flat and conveys stormwater from the site via sheet flow. There are no defined drainage outlets and drainage is generally in a north/northeast direction. Large areas of ponding were noted to the northeast of the site. An existing drainage collection ditch sloping from southwest to northeast is located approximately 130 meters north of the existing main administration building.

3. *PROPOSED DEVELOPMENT*

The additional development on this site proposes to construct a new one-storey warehouse, gravel storage yard and relocate the existing entrance off of Richardson Side Road.

See reduced drawing 2627-GR1 in Appendix A for details.

4. *STORMWATER MANAGEMENT*

No stormwater management controls are specifically required for this site. This brief is intended to summarize the pre and post-development characteristics and drainage rationale.

4.1 *Pre-Development Conditions*

The pre-development weighted runoff coefficient of the site is as follows:

	Area	C	A x C
Paved (sq.m.) =	1,875	0.90	1,688
Rooftop Area (sq.m.) =	325	0.90	293
Gravel Areas (sq.m.) =	900	0.75	675
Grassed Area (sq.m.) =	19,240	0.20	3,848
Total	22,340		6,504

Weighted Runoff Coeff. 'C' $= \frac{A \times C}{A} =$ **0.29**

4.2 *Post-Development Conditions*

The post-development weighted runoff coefficient of the site after construction is as follows:

	Area	C	A x C
Paved (sq.m.) =	2,774	0.90	2,497
Rooftop Area (sq.m.) =	2,419	0.90	2,177
Gravel Areas (sq.m.) =	5,245	0.75	3,934
Grassed Area (sq.m.) =	11,902	0.20	2,380
Total	22,340		10,988

Weighted Runoff Coeff. 'C' $= \frac{A \times C}{A} =$ **0.49**

The proposed expansion of the facilities on this site results in a net increase in runoff. The runoff coefficient has increased from 0.29 to 0.49 due to the inclusion of additional gravel and hard surface areas. Rooftop drainage will be discharged to the surface through downspouts and stormwater will be conveyed via surface drainage to the perimeters of the site where it will be collected by shallow grassed swales.

5. *BEST MANAGEMENT PRACTICES*

Best Management Practices (BMP's) shall be implemented as follows to reduce transport of sediments.

Discharge roof leaders to yards for natural infiltration / evaporation. Roof leaders will not be connected to a storm sewer system. They will discharge onto the ground surrounding the building, which will promote evaporation and infiltration into the ground as much as possible. Grassed swales will be used to convey flows.

Grading to match existing topography as much as possible. The site will be graded to match the existing topography as much as possible.

6. *EROSION AND SEDIMENT CONTROL MEASURES*

In order to mitigate the impact of erosion and sedimentation on receiving watercourses the following measures are proposed for the development:

1. Installation of straw bale dams in existing drainage ditches will be undertaken
2. The extent of exposed soils and cleared areas will be minimized wherever possible
3. Silt fencing will be installed along the north and east perimeters of the site

7. *CONCLUSION*

The proposed expansion of the existing CBC facilities can be implemented without stormwater runoff impacting on the existing structures or the adjacent properties.

Prepared by:	Reviewed by:
David McManus Engineering Ltd.	David McManus Engineering Ltd.
LICENSED PROFESSIONAL ENGINEER June 7/06 K.L. MURPHY 90475369 PROVINCE OF ONTARIO	
Kevin Murphy, P.Eng. Project Engineer	Sean M. Czaharynski, P. Eng. Senior Project Manager

APPENDIX A

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Ph. 225-1929 Fax 225-7330

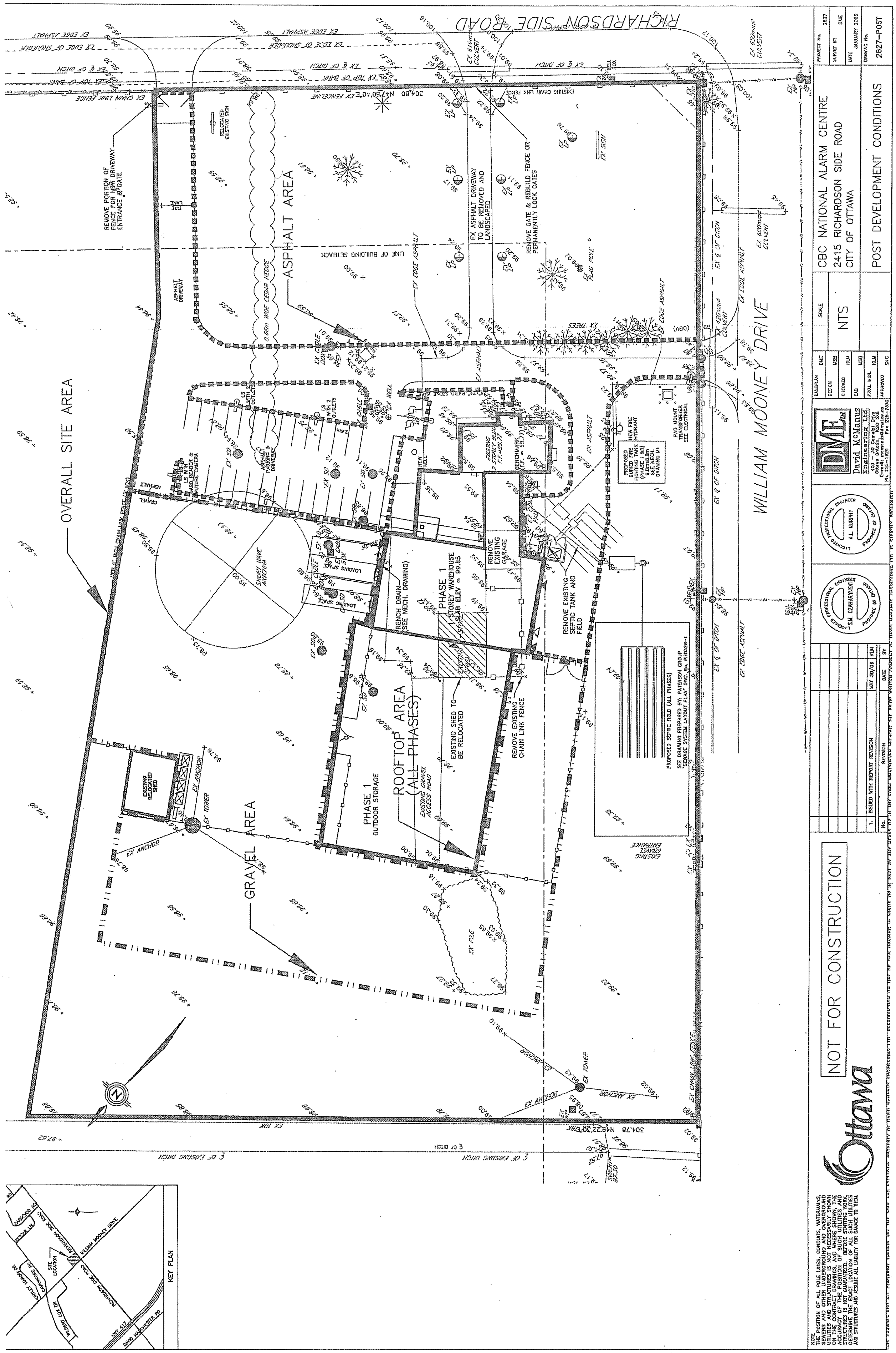
CBC NATIONAL ALARM CENTRE
2415 RICHARDSON SIDE ROAD

PROJECT No. 2627

KEY PLAN

DATE JANUARY 2006

FIGURE 1



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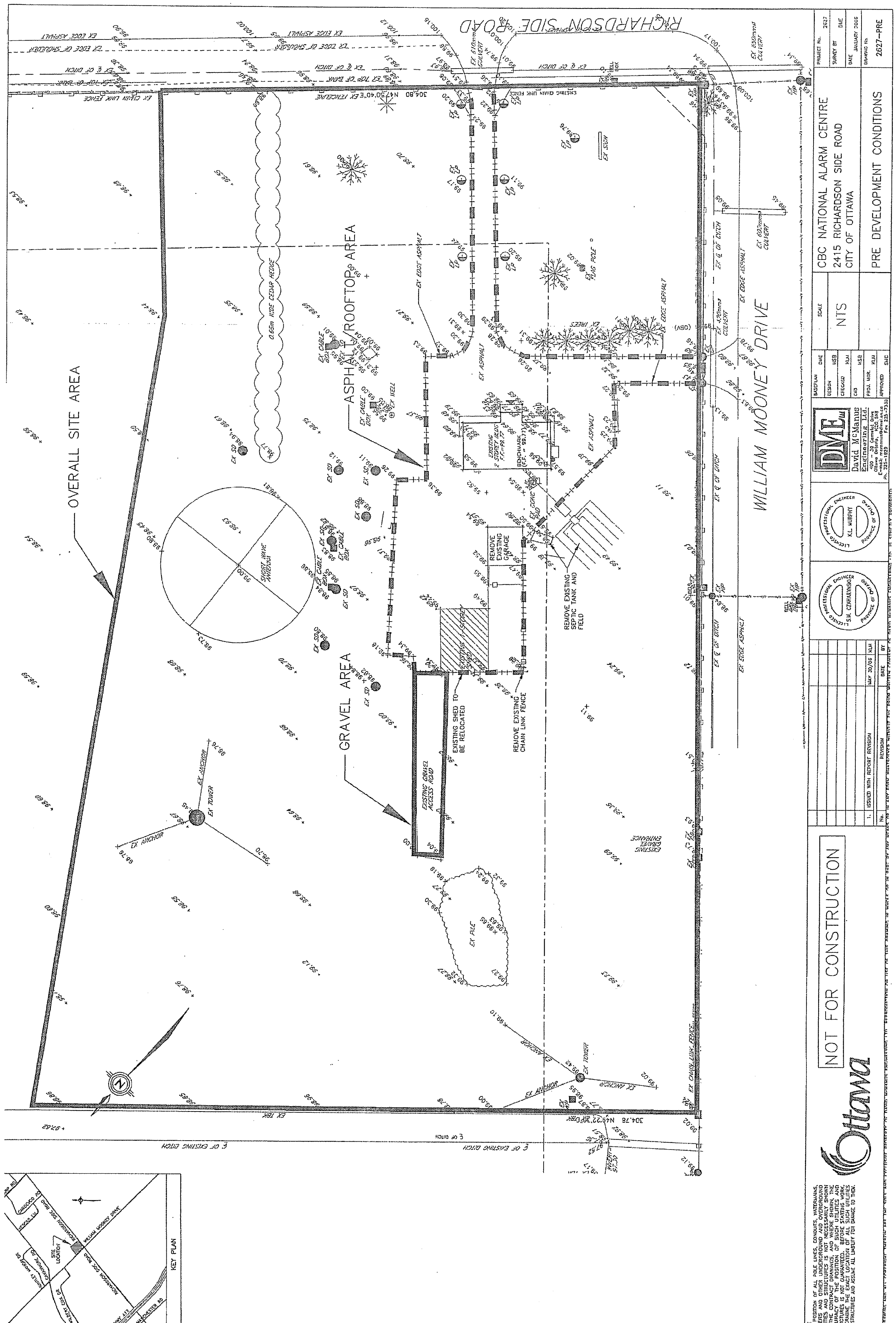

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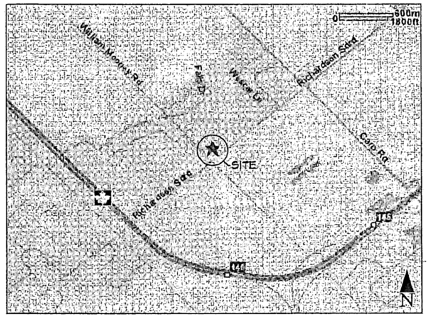
LIST OF DRAWINGS

A1	LOCATION MAP, KEY SITE PLAN & DEMOLITION SITE PLAN
A2	SITE INFORMATION, LOCATION MAP, KEY SITE PLAN & SITE PLAN
2627-GR1	GRADING AND DRAINAGE PLAN
PH0328-1	SEWAGE SYSTEM LAYOUT PLAN
L-1	LANDSCAPE PLAN
A3	DOOR & ROOM FINISH SCHEDULE, DOOR & WINDOW ELEVATIONS & EXISTING SHED INTERIOR DEMOLITION
A4	DEMOLITION ELEVATIONS & PLAN & GROUND FLOOR PLAN
A5	ELEVATIONS, LOADING LOCK RAILING DETAIL & GARBAGE ENCLOSURE DETAILS
A6	ELEVATIONS, BOLLARD DETAIL & BUILDING SECTION
A7	BUILDING SECTION & WALL SECTIONS
A8	WALL SECTIONS
A9	WALL SECTIONS & WASHROOM DETAILS
A10	PLAN DETAILS
A11	SECTION DETAILS
A12	SECTION DETAILS & ROOF CUPOLA DETAILS
S0	GENERAL NOTES & TYPICAL DETAILS
S1	FOUNDATION PLAN, SECTIONS & DETAILS
S2	ROOF FRAMING PLAN, SECTIONS & DETAILS
S3	SECTIONS & DETAILS
M1	MECHANICAL SITE PLAN
M2	MECHANICAL GROUND FLOOR PLUMBING & HVAC LAYOUT
E1	ELECTRICAL SITE PLAN
E2	ELECTRICAL GROUND FLOOR LIGHTING LAYOUT
E3	ELECTRICAL GROUND FLOOR POWER LAYOUT



1 / A1 LOCATION MAP
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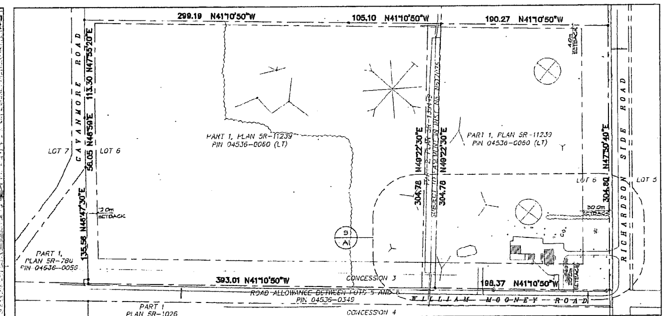

2 / A1 KEY SITE PLAN
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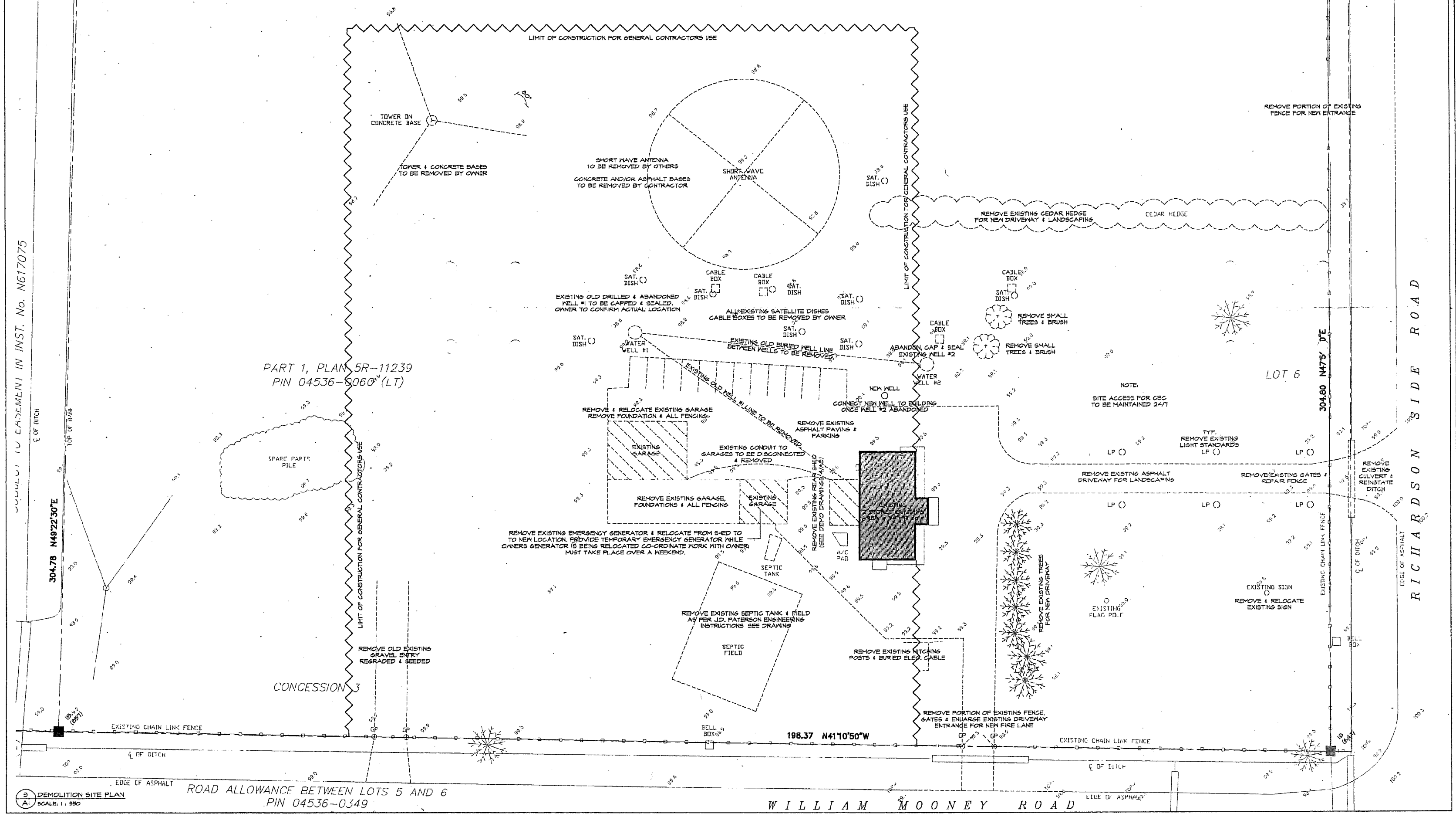

3 / A1 DEMOLITION SITE PLAN
SCALE: 1 : 350

BCDN No.
DAVID MAILING
4064

VERSION NO.
5
10 MAY 2006

NOTES:

- ALL CONTRACTORS MUST COMPLY WITH ALL CODES AND BYLAWS HAVING JURISDICTION.
- IT IS THE RESPONSIBILITY OF THE APPROPRIATE CONTRACTOR TO CHECK & VERIFY ALL DIMENSIONS ON SITE & REPORT ALL ERRORS AND/OR OMISSIONS TO THE ARCHITECT PRIOR TO COMMENCEMENT.
- DO NOT SCALE DRAWINGS.
- DRAWINGS MAY NOT BE USED FOR CONSTRUCTION UNTIL SIGNED BY THE ARCHITECT.

LEGEND

SOLID HATCH = EXISTING BUILDING TO REMAIN

DOTTED LINE = TO BE REMOVED

APPROVED ☑ REFUSED ☐
GRANT C. LINDSAY
Manager
Development Approvals
DATE July 14, 2006

CITY OF OTTAWA RECEIVED JUN 13 2006

NO.	ITEM	DATE
4	ISSUED FOR TENDER	10.05.06
3	REVISIONS AS PER NCC COMMENTS	01.05.06
2	ISSUED FOR BUILDING PERMIT	10.03.06
1	~~ISSUED FOR SITE PLAN CONTROL~~	31.01.06

REVISIONS

NORTH

STAMP
ONTARIO ASSOCIATION OF ARCHITECTS
DAVID MAILING LICENCE

DAVID MAILING Architect INC.
1347 STITTSVILLE MAIN ST.
SUITE ONE
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ONTARIO, K2S 1C6
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PROJECT
CBC NATIONAL ALARM CENTRE
ADDITION & RENOVATION - PHASE I
2415 RICHARDSON SIDE ROAD, OTTAWA

CLIENT
CANADIAN BROADCASTING CORP.
2415 RICHARDSON SIDE ROAD
OTTAWA, ONTARIO, K0A 1L0

DRAWING
LIST OF DRAWINGS
LOCATION MAP, KEY SITE PLAN
DEMOLITION SITE PLAN

SCALE	AS NOTED
DRAWN BY	P.K.
DATE	JAN. 2006
CHECKED BY	J.B.
APPROVED BY	J.B.
PROJECT NO.	205-03

SHEET NO.
A1

D07-12-06-0008

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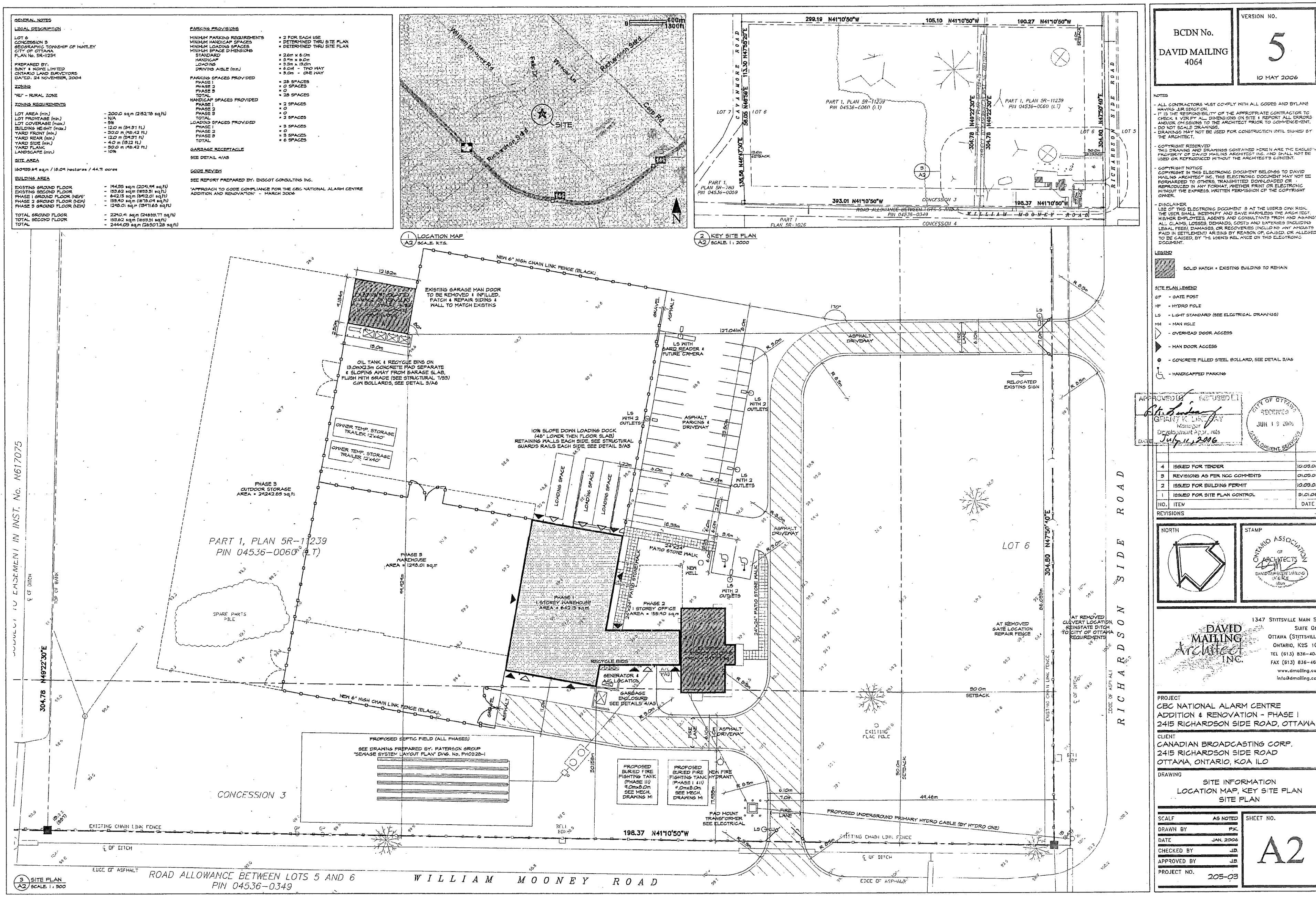

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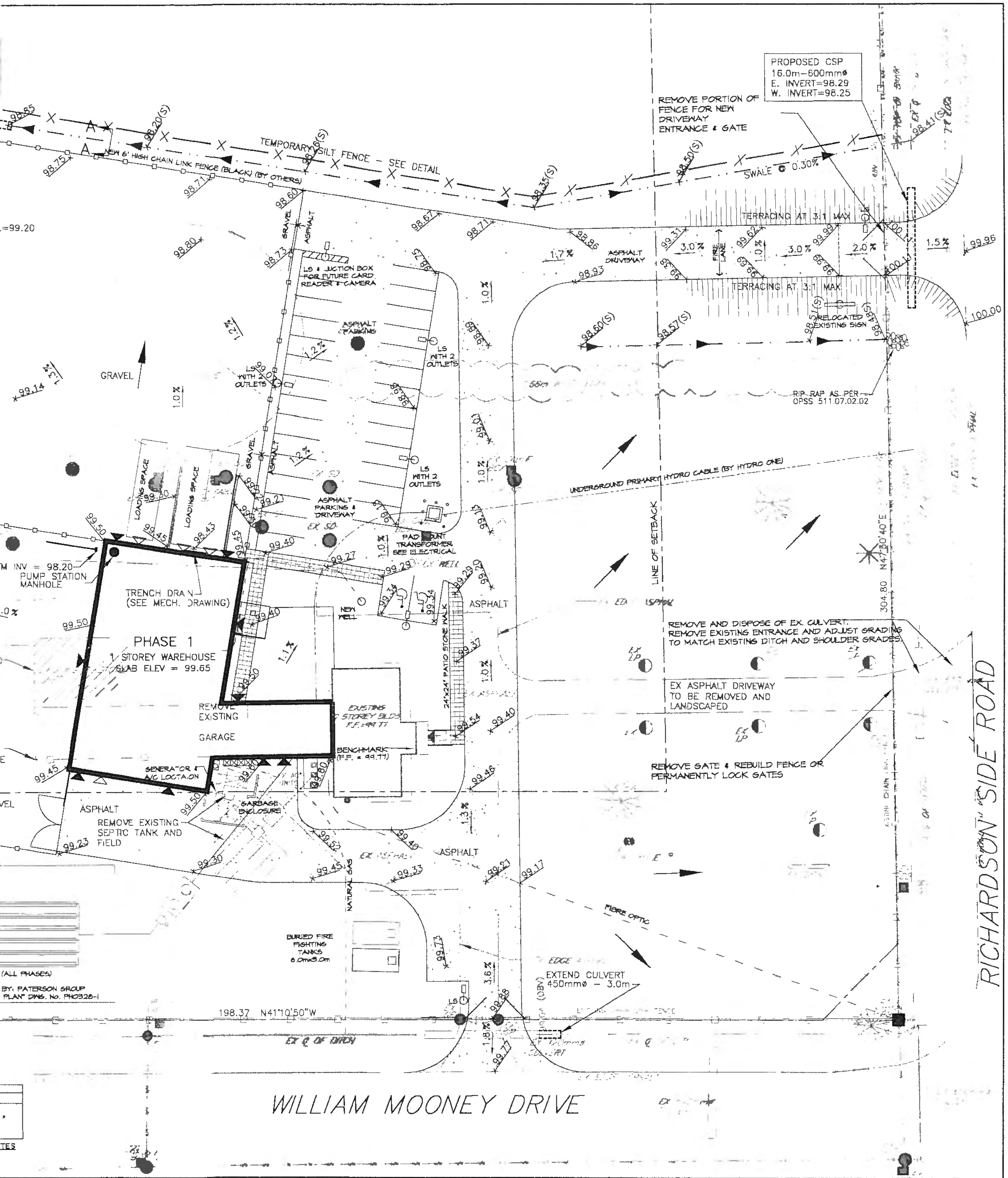

OCT 20/06	SMC
JUN 14/06	SMC
JUN 07/06	SMC
MAY 10/06	SMC
MAY 08/06	SMC
MAR 10/06	SMC
JAN 31/06	KLM
DATE	BY

LICENSED PROFESSIONAL ENGINEER S.M. CZAHARYNSKI PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER K.L. MURPHY PROVINCE OF ONTARIO

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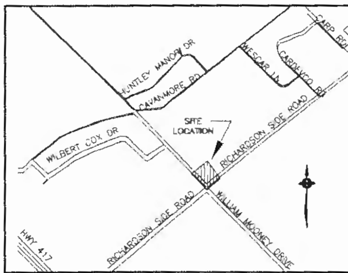
BASEPLAN	DME
DESIGN	MSB
CHECKED	KLM
CAD	MSB
PROJ. MGR.	KLM
APPROVED	SMC

SCALE 1:300
0 3.0 6.0 9.0 12.0

CBC NATIONAL ALARM CENTRE
2415 RICHARDSON SIDE ROAD
CITY OF OTTAWA

GRADING AND DRAINAGE PLAN

PROJECT No.	2627
SURVEY BY	DME
DATE	JANUARY 2006
DRAWING No.	2627-GR1

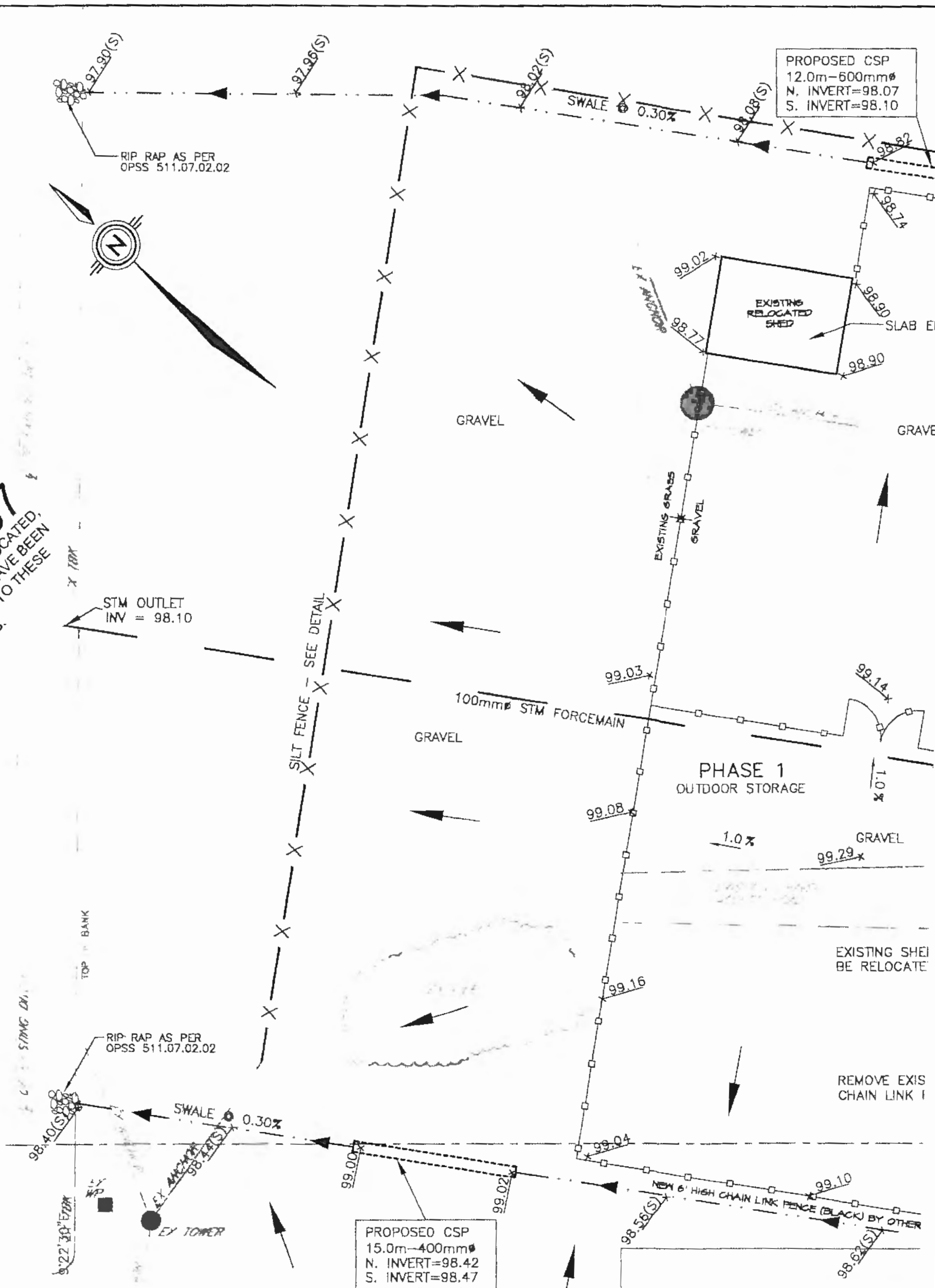


KEY PLAN

LEGEND

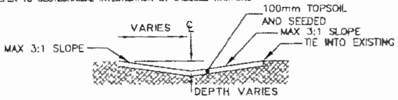
- PROPERTY BOUNDARY
- REARYARD SWALE
- EXISTING LIGHT POLE
- PROPOSED FENCE
- SILT FENCE
- DIRECTION OF FLOW AND SLOPE
- PROPOSED GRADE / EXISTING GRADE
- PROPOSED BUILDING ENTRANCE
- DIRECTION OF OVERLAND FLOW
- EXISTING CHAINLINK FENCE
- HEAVY DUTY ASPHALT
- EXISTING TREE
- EXISTING BELL BOX
- EXISTING HYDRO POLE
- EXISTING GATE POST
- EXISTING OVERHEAD HYDRO AND BELL
- EXISTING MANHOLE
- EXISTING SATELLITE DISH

AS-BUILT
OCT. 25, 2007
ITEMS NOTED AS REMOVED, RELOCATED, SALVAGED OR DEMOLISHED HAVE BEEN COMPLETED ACCORDING TO THESE DOCUMENTS.



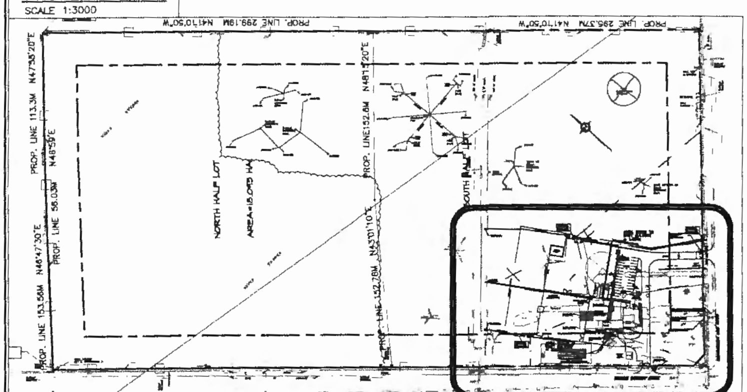
NOTES: GENERAL

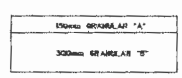
1. CONTRACTOR IS RESPONSIBLE FOR ALL LAYOUT FOR CONSTRUCTION PURPOSES.
2. ALL ELEVATIONS ARE ASSUMED AND UTILIZE METRIC UNITS.
3. JOB BENCH MARK – CONFIRM WITH DAVID McMANUS ENGINEERING PRIOR TO UTILIZATION. (FINISHED FLOOR ELEVATION OF EXISTING OFFICE = 98.77)
4. ALL GROUND SURFACES SHALL BE EVENLY GRADED WITHOUT PONDING AREAS AND WITHOUT LOW POINTS EXCEPT WHERE APPROVED SWALE OR CATCHBASIN OUTLETS ARE PROVIDED.
5. STRIP AND REMOVE ALL TOPSOIL FROM IMPROVED AREAS.
6. COORDINATE AND SCHEDULE ALL WORK WITH OTHER TRADES AND CONTRACTORS.
7. ALL EDGES OF DISTURBED PAVEMENT SHALL BE SAWCUT TO FORM A NEAT AND STRAIGHT LINE PRIOR TO PLACING NEW PAVEMENT.
8. CONTRACTOR IS TO COMPLY WITH CITY OF OTTAWA REQUIREMENTS FOR TRAFFIC CONTROL WHEN WORKING ON MUNICIPAL ROADS.
9. RESTORE PAVEMENT STRUCTURE AND SURFACES ON EXISTING ROADS TO A CONDITION AT LEAST EQUAL TO ORIGINAL AND TO THE SATISFACTION OF THE MUNICIPAL AUTHORITIES.
10. ALL MATERIAL SUPPLIED AND PLACED FOR PARKING LOT AND ACCESS ROAD CONSTRUCTION SHALL BE TO OPSS STANDARDS AND CITY OF OTTAWA STANDARDS UNLESS OTHERWISE NOTED. (CONSTRUCTION OPSS 206, 310 & 314 MATERIALS OPSS 1001, 1003 & 1010).
11. REFER TO ARCHITECT'S SITE PLAN FOR BUILDING DIMENSIONS, SITE LAYOUT AND REMOVALS. DIMENSIONS AND LAYOUT INFORMATION SHALL BE CONFIRMED PRIOR TO CONSTRUCTION.
12. REFER TO LANDSCAPE ARCHITECT'S PLAN FOR SIDEWALK, PATHWAYS, CONCRETE MEDIAN, PLANTING AND OTHER LANDSCAPE FEATURE MATERIALS AND LOCATIONS.
13. EXISTING CONCRETE SLAB, PAVEMENT AND GRAVEL TO BE REMOVED FROM SITE.
14. THE CONTRACTOR SHALL COMPLY WITH THE GEOTECHNICAL REPORT FOR PAVEMENT STRUCTURE AND SLAB ON GRADE CONSTRUCTION. REMOVE ALL SURFICIAL VEGETATION, EXISTING ASPHALT, CURB (ETC.) LOCATED WITHIN DESIGNATED AREAS OF PROPOSED CONSTRUCTION. REMOVE AND/OR RELOCATE PIPES, APPURTENANCES, STRUCTURES, ETC. THAT ARE DESIGNATED FOR REMOVAL AND/OR RELOCATION. REGRADE EXISTING GRANULARS TO PROPOSED GRADES, SUPPLY AND INSTALL GRANULARS AS REQUIRED TO ACHIEVE PROPOSED GRADES. ALL MATERIAL DESIGNATED BY THE ENGINEER AS EXCESS TO THE REQUIREMENTS OF THIS WORK SHALL BE LOADED HAULED AND DISPOSED OF OFF SITE BY THE CONTRACTOR. LOOSE SUBGRADE TO BE RECOMPACTED, SOFT AREAS SHALL BE SUBEXCAVATED, WITH A 5:1 TRANSITION TAPER TO FIRM SUBGRADE, AND BACKFILLED WITH SELECT SUBGRADE MATERIAL.
15. REFER TO GEOTECHNICAL INVESTIGATION BY JACQUES WHITFORD



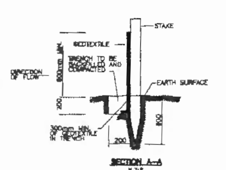
SECTION A – A
TYPICAL SWALE DETAIL
NOT TO SCALE

PROPERTY LIMITS
SCALE 1:3000



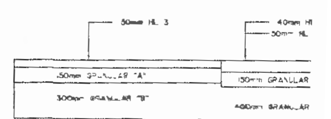


GRAVEL AREAS
N.T.S.



SECTION A-A

PLAN OF SILT FENCE BARRIER
N.T.S.



PARKING AREAS
(LIGHT DUTY)
N.T.S

MAJOR ACCE
(HEAVY
N.T.S

NOTE
THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

Ottawa

No	REVISION	DATE	BY	No	REVISION
				7.	POST TENDER REVISIONS
				6.	ISSUED FOR FINAL APPROVAL
				5.	INSERT PROPERTY LIMITS PLAN
				4.	ISSUED FOR TENDER
10.	AS CONSTRUCTED DRAWINGS (BY PK-DMAA)	OCT 25/07		3.	REVISED SITE PLAN
9.	ADDITION OF CULVERTS IN EAST AND WEST SWALE	MAY 15/07	SMC	2.	ISSUED FOR BUILDING PERMIT
8.	REVISED SWALE GRADES	NOV 23/06	SMC	1.	ISSUED FOR SITE PLAN APPLICATION

Site Plan Pre-Consultation

Meeting Date: 2019.07.29

2415 Richardson Side Road

Applicant:	Pye & Richards Architect Inc.	**Consultant:**	Gordon Krieg
Ward	5-West Carleton-March	**Councillor**	Eli El-Chantiry

Proposal Summary: To construct a 1,050 square metre one storey storage building for CBC films. There will be no fulltime occupants in the building as it will be managed by the staff of the existing building. Original site plan for office building and warehouse was approved in 2006.

Attendees:
Gordon Krieg, Principal, Pye & Richards Architect Inc.
Jean-Pierre Cheff, Project Manager, BGIS
Andy Naoum, Senior Consultant, Capital Engineering Group Ltd.
Sami Rehman, Environmental Planner, PIEDD, City of Ottawa
Rubina Rasool, Project Manager, PIEDD, City of Ottawa
Anne Wang, Planner, PIEDD, City of Ottawa
Krishon Walker, Planner, PIEDD, City of Ottawa

Meeting Notes

Planning Comments (Provided by Krishon Walker)

- As per Schedule A of the Official Plan the site is designated General Rural Area, and the site is within the boundary of the Carp Road Corridor Community Design Plan.
- Please ensure that your proposal complies with all applicable provisions under the Rural Countryside Zone, of the Zoning By-law. I am still awaiting confirmation from our policy team regarding whether or not the proposed use would be permitted on the property without the need for any additional applications. I will update you once I know more.
- Please note that as per Part 4 of the Zoning By-law, there are no additional parking spaces required for the addition.
- Proposal presented at the meeting is smaller than what was originally indicated in the previous site plan approval (*not part of the approval but was indicated that there will be a subsequent phase*).
- The proposed structure (*warehouse*) will be used for film canister storage and will be temperature controlled (*7 degrees)* and secured.
- Additional gravel storage area should be identified on the site plan the extend of the storage expansion.
- Please show the location for snow storage on Site Plan and Landscape Plan. Storage shall not interfere with approved grading and drainage patterns or servicing. If snow is to be removed from the site, then please make a note of that on the Site Plan and include where the snow will be placed in the interim. Temporary snow storage areas should not conflict with utility box, landscaping, required parking, and site circulation.
- As mentioned in my previous email, a TIA report is not required as the site's generated volumes will not trigger a TIA and no new driveways are proposed.
- After discussions with our Legal Department, since the original application for the Site Plan Control was received prior to January 1, 2007, given the timing, the supporting documents cannot be considered in the public domain. However, if you were to submit an Access to Information request referencing application D07-12-06-0028, we would very likely provide the documents through that channel. Information on ATIP: https://ottawa.ca/en/city-hall/accountability-and-transparency/accountability-framework/freedom-information-and-protection-privacy/access-information#how-and-where-submit-request-information.
- Be sure to follow the City's guide to preparing plans and studies (see link below) to ensure the quality of your submission.
- **NOTE:** The deadline (*March 2020*) to relocate the film canisters from an existing location in Montreal is very optimistic and does not seem realistic. I would strongly suggest that you look at alternatives.

Prepared by K. Walker
Date: August 13, 2019

Engineering Comments (Provided by Rubina Rasool)

Water and Sanitary

- The following is applicable if the proposed addition will be connected to the water and sewage system.
- The hydrogeology and terrain analysis shall discuss the new demands can be accommodated with the existing well and septic system.
- A Groundwater Impact Study will be required for design flows exceeding 10,000 L/day.
- Septic permit submitted to the Ottawa Septic System Office.

Stormwater Management

- The consultant should determine a stormwater management regime for the application and maintain post-development flows to pre-development levels by way of providing storage to offset increased impervious areas.
- For the purpose of the site plan control application the pre-development conditions will be based on the City approved grading and drainage plan and stormwater management report.
  - Grading and Drainage Plan, CBC National Alarm Center, 2415 Richardson Side Road, 2627-GR1 prepared by David McManus Engineering Ltd., dated January 2006, revised June 14, 2006 and dated as received by the City of Ottawa on June 19, 2006.
  - Storm Servicing Brief, prepared by David McManus Engineering Ltd., dated May 30, 2006, revision 1.
- The stormwater management system should be designed for the 5-year post-development to 5-year pre-development and the 100-year post-development to 100-year predevelopment storm events.
- Overland flows should be directed to a legal outlet or watercourse. Where possible the City would prefer to drain towards the roadside ditch in to increase retention time.
- Any existing stormwater runoff from adjacent site(s) that crosses the property must be accommodated by the proposed stormwater management design.
- Water quality design requirements will be determined by the Mississippi Valley Conservation Authority.
- All stormwater management determinations shall have supporting rationale.

Fire Protection

- The applicant should have their consultant contact Ottawa Fire Services to determine if fire protection is required.
  Contact Information:
  Allan Evans
  Engineer, Fire Protection
  City of Ottawa
  613-580-2424 x24119
  Allan.Evans@ottawa.ca

Easement

- The applicant shall identify all easements on site and provide the legal easement agreement as part of their submission.

Snow Storage

- Any portion of the subject property which is intended to be used for permanent or temporary snow storage shall be as shown on the site plan and grading plan. Snow storage shall not interfere with grading and drainage patterns. Snow storage areas shall be setback from the property lines, foundations, fencing or landscaping a minimum of 1.5m. Snow storage areas shall not occupy driveways, aisles, required parking spaces or any portion of a road allowance.

Permits and Approval

- Please contact the Mississippi Valley Conservation Authority (MVCA), amongst other federal and provincial departments/agencies, to identify all the necessary permits and approvals required to facilitate the development: responsibility rests with the developer and their consultant for obtaining all external agency approvals. The address shall be in good standing with all approval agencies. Copies of confirmation of correspondence will be required by the City of Ottawa from all approval agencies that a form of assent is given. No construction shall commence until after a commence work notification is given.

Contact Information:
Niall Oddie
Environmental Planner
Mississippi Valley Conservation Authority
613 253 0006 ext. 229
noddie@mvc.on.ca

Easement

- The applicant shall identify all easements on site and provide the legal easement agreement as part of their submission.

Environmental Comments (Provided by Sami Rehman, Environmental Planner)

- The subject property is part of the Natural Heritage System (See OP Section 2.4.2 and Schedule L3), which would normally trigger an Environmental Impact Statement (EIS), as per OP Section 4.7.8. The subject property does have significant woodlands, unevaluated wetlands and potential habitat for threatened or endangered species.
- Given that the proposed development is outside of the natural features, however, a scoped EIS to address potential habitat for threatened or endangered species would be acceptable.
- The proposed development (which includes site alteration) is also near a watercourse bisecting the subject property. As such, it is recommended that the EIS also address the appropriate setback from the watercourse as outlined in policy #2, OP Section 4.7.3.
- The EIS should also address how any existing trees will be protected or compensated for.
- It is recommended that the you consult with the Mississippi Valley Conservation Authority to determine if any permits or approvals are required under their regulations.

ADDITIONAL COMMENTS

Planning Comments

Official Plan: General Rural Area

Secondary Plan and/or Community Design Plan: Carp Road Corridor Community Design Plan

Zoning By-law: RU – Rural Countryside Zone

1. Setbacks and related Provisions (everything is in metres unless noted otherwise):

   Minimum lot width: 50m
   Minimum lot area (in hectares): .8
   Minimum front yard setback: 10m
   Minimum rear yard setback: 10m
   Minimum interior side yard setback: 5m
   Minimum corner side yard setback: 10m
   Maximum building height: 12m
   Maximum lot coverage: 20%
   Minimum distance separation: see Part 2, Section of the Zoning By-law

2. Parking:
   - All parking must comply with Part 4 (Sections 100-114) of the Zoning By-law.

3. Garbage Enclosure:

    - All outdoor refuse collection areas must comply with Section 110(3) of the Zoning By-law.

4. Parkland Dedication:

    - Pursuant to Section 14(1) of Parkland Dedication By-law 2009-05, as amended, as the proposed development is for government use (i.e., CBC), parkland dedication is not required

The required Planning Rationale needs to demonstrate compliance to all relevant and applicable Official Plan and Community Design Plan policies and Zoning By-law provisions.

- For more information on the Official Plan designation and the relevant Community Design Plan, please visit: https://ottawa.ca/en/city-hall/planning-and-development/official-plan-and-master-plans/official-plan/volume-1-official-plan/section-3-designations-and-land-use#3-7-rural-designations and https://ottawa.ca/en/city-hall/planning-and-development/community-plans-and-design-guidelines/community-plans-and-studies/community-design-plans/carp-road-corridor-community-design-plan
- For more information and related Zoning By-law provisions, please visit: https://ottawa.ca/en/part-13-rural-zones-sections-211-236#ru-rural-countryside-zone-sections-227-and-228

Environmental Comments

Additional Comments from the Mississippi Valley Conservation Authority are forthcoming.

Engineering Comments:

Site Plan Control Engineering Reports:

- Geotechnical Report
    - Earthquake and liquefaction analysis is now required in the report.
    - Please note that the area may contain sensitive marine clays. Atterberg limits, consolidation testing, shear strength testing, grade raise restriction, sieve analysis, and discussion thereof, amongst other data, will be required in if sensitive marine clay, or similar conditions are found.
    - The geotechnical consultant will need to provide full copies of any published and peer reviewed papers relied on to determine results and conclusions.
- Hydrogeology and Terrain Analysis (if applicable)
    - The existing hydrogeology report may be used provided an relevant licenced professional can confirm that the previous hydrology study is still reflective of the current hydrogeology and terrain analysis.
    - The brief shall demonstrate the quality of drinking water by performing a water sample tests prior to treatment.
    - If the water quality requires treatment the brief should clearly discuss the treat methods to achieve acceptable water quality to MECP standards.
    - The hydrogeology report should discuss if the existing pump test is meets the requirements for the new demand. All calculations shall be clearly provided.
    - The hydrogeology analysis should provide a pump test in accordance to MECP requirements.
    - The terrain analysis shall clearly demonstrate the suitability of the soils to adequate support a septic system at this location and the capacity of dilution.
- Servicing Report
- Stormwater Management Report

Site Plan Control Engineering Reports:

- Grading and Drainage Plan
- Servicing Plan
- Sediment and Erosion Control Plan
    - The Erosion and Sediment Control Plan should manage all loose material from being transporting into adjacent properties and waterways. The Conservation Authority should be consulted to determine any additional measures that may be required.

As per section 53 of the Professional Engineers Act, O. Reg 941/40, R.S.O. 1990, all documents prepared by engineers must be signed and dated on the seal.

Application Submission Information

Application Type: Rural Standard – Staff Approval.
Application processing timeline generally depends on the quality of the submission. For more information on standard processing timelines, please visit: https://ottawa.ca/en/city-hall/planning-and-development/information-developers/development-application-review-process/development-application-submission/development-application-forms#site-plan-control

Prior to submitting a formal application, it is recommended that you pre-consult with the Ward Councillor.

For information on application fees, please visit: https://ottawa.ca/en/city-hall/planning-and-development/information-developers/development-application-review-process/development-application-submission/fees-and-funding-programs/development-application-fees

To request City of Ottawa plan(s) or report information please contact the City of Ottawa Information Centre: InformationCentre@ottawa.ca or (613) 580-2424 ext. 44455

Application Submission Requirements

For information on the preparation of Studies and Plans and the City's requirements, please visit: https://ottawa.ca/en/city-hall/planning-and-development/information-developers/development-application-review-process/development-application-submission/guide-preparing-studies-and-plans

Please provide electronic copy (PDF) of all plans and studies required.

All plans and drawings must be produced on A1-sized paper and folded to 21.6 cm x 27.9 cm (8½"x 11").

Note that many of the plans and studies collected with this application must be signed, sealed and dated by a qualified engineer, architect, surveyor, planner or designated specialist.

Andy Naoum

From: Gord Krieg <gord.krieg@pnrarch.com>
Sent: September 4, 2019 2:39 PM
To: Jean-Pierre Cheff
Cc: Andy Naoum
Subject: FW: 2415 Richardson Side Road - Pre-consult Meeting Notes
Attachments: O.Reg Mapping.pdf

Jean-Pierre

More bad news. Zoning is now requiring a re-zoning of the property. This is another long process. Can you advise the client and provide me with direction? I'm not sure why this addition is being treated differently than the previous. We can do a pre-consult with the City on the re-zoning and then decide on our course of action. Let me know if I should do this.

Andy, sending you this for the MVCA info only.

Thanks.

Gord Krieg, B.E.S., B.Arch.

PYE & RICHARDS ARCHITECTS INC.
200-824 Meath Street,
Ottawa, Ontario. K1Z 6E8
p. 613-724-7700 x.53
c. 613-301-2925
e. gord.krieg@pnrarch.com
w. www.pyeandrichardsarchitects.com

From: Walker, Krishon <krishon.walker@ottawa.ca>
Sent: September 4, 2019 2:30 PM
To: Gord Krieg <gord.krieg@pnrarch.com>
Subject: RE: 2415 Richardson Side Road - Pre-consult Meeting Notes

Hi Gord,

I have heard from the MVCA. Attached is a copy of the MVCA mapping for the property, which indicates that the property is bisected by a tributary to Huntley Creek and two headwater features draining northward into the watercourse. The proposal appears to situate the building closer to one of the headwater features. A permit would be required for any alteration to this watercourse. Regarding SWM, Huntley Creek requires enhanced treatment (80% TSS removal) and thermal control to a maximum of 25 degrees Celsius. The MVCA would recommend controlling post-development runoff to pre-development levels.

Additionally, I have an update for you in regards the zoning for the property. After having discussions with the Zoning By-law Interpreters and other members of my team, you will require a Zoning By-law Amendment to permit the proposal as a warehouse is not a permitted use in the RU zone. The previous approval in 2006 was for a warehouse, training facility, and storage facility that was accessory to the office and monitoring facility. The department is of the opinion that the proposed warehouse to store film cannisters is not accessory to the monitoring facility and wouldn't have been permitted under the previous Zoning provisions, therefore, is not considered an existing use. I can schedule a pre-consultation meeting to go over what is required for the Zoning By-law Amendment application. You can find more information here: https://ottawa.ca/en/city-hall/planning-and-development/information-developers/development-application-review-process/development-application-submission/development-application-forms#zoning-law-amendment.

If you have any questions, please do not hesitate to let me know.

Best Regards,
Krishon Walker
Planner I | Urbaniste I
Development Review | Examen des projets d'aménagement
Planning, Infrastructure and Economic Development | Services de planification, d'infrastructure et de développement économique

City of Ottawa | Ville d'Ottawa
☎ 613.580.2424 ext./poste 24161
ottawa.ca/planning / ottawa.ca/urbanisme

From: Gord Krieg <gord.krieg@pnrarch.com>
Sent: August 26, 2019 2:22 PM
To: Walker, Krishon <krishon.walker@ottawa.ca>
Subject: RE: 2415 Richardson Side Road - Pre-consult Meeting Notes

Any word on the Conservation Authority comments or do we deal with them directly? Let me know. Thanks.

Gord Krieg, B.E.S., B.Arch.

PYE & RICHARDS ARCHITECTS INC.
200-824 Meath Street,
Ottawa, Ontario. K1Z 6E8
p. 613-724-7700 x.53
c. 613-301-2925
e. gord.krieg@pnrarch.com
w. www.pyeandrichardsarchitects.com

From: Walker, Krishon <krishon.walker@ottawa.ca>
Sent: August 14, 2019 10:24 AM
To: Gord Krieg <gord.krieg@pnrarch.com>; 'jean-pierre.cheff@bgis.com' <jean-pierre.cheff@bgis.com>; 'cegl@rogers.com' <cegl@rogers.com>
Cc: Rasool, Rubina <Rubina.Rasool@ottawa.ca>; Rehman, Sami <Sami.Rehman@ottawa.ca>; Walker, Krishon <krishon.walker@ottawa.ca>
Subject: 2415 Richardson Side Road - Pre-consult Meeting Notes

Good morning,

Please find attached the notes from our meeting on July 29, 2019 in reference to the Site Plan Control application for 2415 Richardson Side Road. I have also attached the List of Plans and Studies required for the application submission. For ease of reference, I have copied Sami Rehman (environmental planner) and Rubina Rasool (project manager).

If you have any questions or need clarification about anything, please do not hesitate to let me know.

Best Regards,

Krishon Walker
Planner I | Urbaniste I
Development Review | Examen des projets d'aménagement
Planning, Infrastructure and Economic Development | Services de planification, d'infrastructure et de développement économique

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Mississippi Valley Conservation Authority

Ontario Regulation 153/06

2415 Richardson Side Road

Legend

Property - Parcels

- Stable Slope Hazard
- Meander Belt
- 1:100 yr Flood Plain
- Floodplain Study Limit
- MVCA Regulation Limit
- Provincially Significant Wetlands
- Non Evaluated Wetlands
- Locally Significant Wetlands
- Regulation Limit Other Wetlands 30m
- MVCA Streams
- Waterbodies

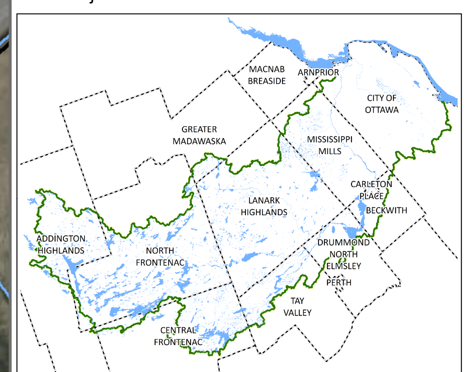
0 0.05 0.1

km

1:3,000

N W E S

Projection: UTM Zone 18- NAD 83 Datum



This map is produced in part with data provided by the Ontario Geographic Data Exchange under License with the Ontario Ministry of Natural Resources and the Queen's Printer for Ontario, 2019

Imagery @ Fugro Geospatial, May 2014

Date: 7/19/2019

Water Qual. Res. J. Canada, 2006 • Volume 41, No. 3, 275–282

Effectiveness of Vegetative Filter Strips in Removal of Sediments from Overland Flow

Bahram Gharabaghi,[1]* Ramesh P. Rudra[1] and Pradeep K. Goel[2]

[1]*School of Engineering, University of Guelph, Guelph, Ontario N1G 2W1*
[2]*Water Monitoring Section, Ministry of the Environment, 125 Resource Road, Etobicoke, Ontario M9P 3V6*

Many forms of natural heritage manifested as streams, rivers, ponds, lakes and wetlands play an integral role in maintaining natural beauty, health and a high quality of life. Agricultural intensification in southern Ontario has contributed to elevated sediments, nutrient and bacteria levels in water bodies. Vegetative filter strips (VFS) are control measures that can partially remove sediments and pollutants adhered to sediments from overland runoff before entering water bodies. The objective of this study was to determine the effect of vegetation type, width of the filter strip, runoff flow rate and inflow sediment characteristics on effectiveness of the VFS in removing pollutants from runoff. The results show that sediment removal efficiency increased from 50 to 98% as the width of the filter increased from 2.5 to 20 m. In addition to the width of the filter strip, grass type and flow rate were also significant factors. This study indicates that the first five (5) metres of a filter strip are critical and effective in removal of suspended sediments. More than 95% of the aggregates larger than 40 µm in diameter were trapped within the first five metres of the filter strip.

Key words: **vegetative filter strips, water quality, stormwater management**

Introduction

The *Clean Water Act* and the *Nutrient Management Act* passed recently in the Ontario legislature have put in motion a massive science-based effort to better understand and protect our drinking water sources. Sediment, nitrogen, phosphorus and bacteria are primary pollutants associated with surface runoff from agricultural fields (McLeod and Hegg 1984; Edwards et al. 1983). Environmental concern related to nutrient loss and appearance of sediments and sediment-bound contaminants at higher than recommended levels in water systems can be addressed by adopting better management options. Major investments are being made in Ontario to control point and non-point pollution sources.

During the recent past, vegetative filter strips (VFS) have become an important best management practice (BMP) to control pollutant transport by stormwater runoff and are used widely in the United States to enhance the quality of stream ecosystems (Schellinger and Clausen 1992; Mickelson and Baker 1993; Chaubey et al. 1994; Patty et al. 1997; Egball et al. 2000; Fajardo et al. 2001; Boyd et al. 2003). Numerous studies have clearly advocated the effectiveness of vegetative filter strips as the first defense mechanism in the multi-tier approach of reducing pollutant transport from agricultural fields.

Dickey and Vanderholm (1981) studied feedlot runoff and found that VFS can remove up to 95% (on mass basis) of nutrients and oxygen-demanding materials from the incoming runoff with concentration reductions of up to 80%. However, Dillaha et al. (1988) observed a significant reduction in the sediment trapping efficiency of VFS when flow regimes changed from uniform to concentrated flow. Lammers et al. (1991) also observed similar results in a survey of buffer strips in Virginia and concluded that buffer strips were not very effective when water collects in natural drainage ways prior to crossing the buffer strips.

Chaubey et al. (1994) observed a mass reduction of total suspended solids (TSS) and total phosphorus (TP) in surface runoff by 66 and 27%, respectively, with a 4.6-m wide filter strip. They also observed an improvement in the ammonia and P removal from swine lagoon effluent with an increase in filter strip width. Such reductions can be attributed to a decrease in flow velocity and the retarding effect of vegetation; however, the reductions in the concentration of soluble pollutants were not as significant (Edwards et al. 1996; Srivastava et al. 1996; Robinson et al. 1996; Lim et al. 1998).

Schmitt et al. (1999) suggested that VFS were more effective in the reduction of particulate pollutant concentration but have less effect on the concentration of soluble pollutants. They investigated the performance of different filter strip widths and concluded that filter strips of 7.5 and 15 m in width can result in 76 and 93% sediment removal efficiencies.

Oelbermann and Gordon (2000) evaluated the performance of the VFS by comparing the pollutant con-

* Corresponding author; bgharaba@uoguelph.ca

centrations in runoff at the inlet and outlet of the VFS. They concluded that, if properly installed and maintained, VFS have the capacity to remove up to 75% or more of the sediments and sediment-bound pollutants from cropland runoff.

Lee et al. (2000) observed that the concentration-based removal efficiency of sediment-bound nutrients (N and P), in general, followed similar trends as total suspended sediments. Moreover, Abu-Zreig et al. (2003) found that sediment removal efficiency of VFS varied directly with the width of the filter strip, and inversely with the magnitude of runoff flow rate.

Further studies are needed to establish the mechanisms that regulate the transport, deposition and reentry of sediments and sediment-bound contaminants during lateral movement of stormwater runoff through VFS. There is a need to establish design procedures useful for the selection of vegetation and the width of the filter strip effective for protecting receiving water quality for specific site characteristics of runoff, geomorphology and soil. Therefore, in this study field experimentation was conducted to evaluate the effectiveness of VFS under different vegetation, filter strip width and flow rate in removal of suspended sediments from overland flow. The results of this study are being used for the development of the Guelph Design Tool for Vegetative Filter Strips (GDVFS).

Materials and Methods

Field experiments were conducted in the summer of 1998 in the Carol Creek Farm near Elora, Ontario; in the summer of 2000 and 2002 at the Guelph Turf Grass Institute and Environmental Research Centre, Guelph, Ontario; and in the summer of 2003 and 2004 at the Elora Research Farm, University of Guelph, Elora, Ontario, to evaluate the runoff treatment performance of VFS under various grass types, filter strip width, flow rate and sediment load conditions. The range of observational parameters for each site is shown in Table 1.

Vegetation in the Filter Strip

Six different vegetation cover types have been tested, including: Type A—an equal mixture of Perennial Ryegrass (*Lolium perenne* L.), Kentucky Bluegrass (*Poa pratensis* L.) and Reed Canarygrass (*Phalaris arundinacea* L.); Type B—a mixture of Birdsfoot Trefoil (*Lotus corniculatus* L.) and Creeping Red Fescue; Type C—existing native vegetation, undisturbed for many years, consisting of native species including wild oat, quack, tall fescue grass and dandelions; Type D—Perennial Ryegrass; Type E—an equal mixture of Perennial Ryegrass and Red Clover (*Trifolium pratense* L.); and Type F—Kentucky Bluegrass.

Perennial Ryegrass is a very fast germinating grass that spreads well under full sun conditions; Kentucky Bluegrass produces a high-quality dense grass but it is slow to establish and does not tolerate prolonged wet or drought conditions; Reed Canarygrass is more climate-tolerant grass but is slow to establish; Birdsfoot Trefoil is a legume that tolerates well wet soil conditions; the Red Clover grows and spreads on most soils and has a good winter hardiness and fair drought tolerance.

Dimensions of the Filter Strip Plots

The length of the vegetative filter plots represents the width of the grass buffer strips along the stream, which is the most significant design parameter for a vegetative filter strip. The plot lengths at the Carol Creek Site were 5, 10 and 15 m; for each length three plots were constructed with different grass cover types (A, B and C); that is, a combination of three vegetation cover types (A, B and C) and three plot lengths resulted in nine different plots constructed at this site. Similarly, at the Elora Research Farm site nine plots were constructed to test three new vegetation cover types (D, E and F) on three plot lengths (5, 10 and 15 m). However, at the Guelph Turfgrass Institute site four plots were constructed to test only one vegetation cover type (D) on four plot lengths of 2.5, 5, 10 and 20 m. As shown in Fig. 1, these plots were constructed parallel to each other on a hill of uniform slope of about 5%.

TABLE 1. Range of observational parameters at each site[a]

	Carol Creek Site 1998	*Guelph Turf. Inst. Site 2000/02*	*Elora Research Farm 2003/04*
Grass type[b]	A, B and C	D	D, E and F
Filter strip width (m)	5, 10 and 15	2.5, 5, 10 and 20	5, 10 and 15
Flow rate (L/s)	0.30–1.20	0.29–2.11	0.50–1.50
Sediment load (mg/L)	887–2597	105–8525	1514–6418
Total number of runs	32	72	33

[a]Note: no true replicates were completed in this study.

[b]Grass type A—an equal mixture of Perennial Ryegrass (*Lolium perenne* L.), Kentucky Bluegrass (*Poa pratensis* L.) and Reed Canarygrass (*Phalaris arundinacea* L.); Type B—a mixture of Birdsfoot Trefoil (*Lotus corniculatus* L.) and Creeping Red Fescue; Type C—existing native vegetation, consisting of native species including wild oat, quack, tall fescue grass and dandelions; Type D—Perennial Ryegrass; Type E—an equal mixture of Perennial Ryegrass and Red Clover (*Trifolium pratense* L.); and Type F—Kentucky Bluegrass.

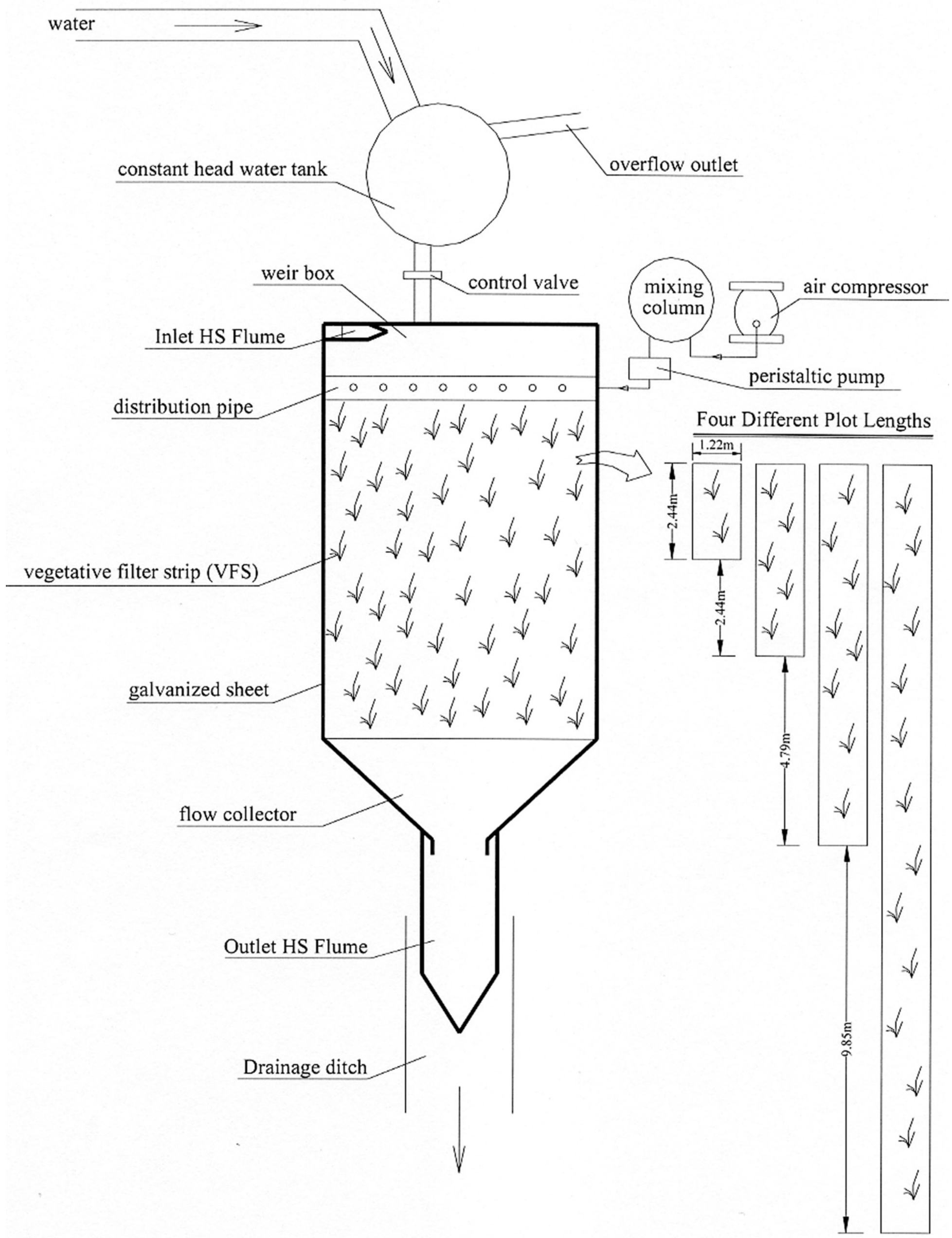


Fig. 1. Schematics of field experiment setup for the Guelph Turfgrass Institute site.

Thirty-centimetre wide galvanized sheets were inserted along the sides of the plots and a flow collector was used at the outlet. All plots were constructed 1.2 m (4 feet) wide to ensure a uniform sheet flow with a depth-to-width ratio of less than 5% to minimize the wall effect.

Flow Rates

At the Guelph and Elora sites, water was supplied from a pressurized irrigation system using fire hoses to two large constant head tanks mounted on a trailer parked upstream of the plots, which could supply a steady flow rate of slightly more than 2 L/s (Fig. 1). A 1.2-m wide weir box was used at the inlet to distribute the flow evenly across the plot. Flow rates typically ranged from 0.30 to 2.00 L/s, measured at both upstream and downstream ends of the filter strips using HS flumes. The plots were pre-wetted with clear water for about an hour before the tests began to ensure a steady-state infiltration rate.

Inflow Sediment Concentrations

For all three sites, a steady-state flow stream of known flow rate and sediment concentration was introduced uniformly at the inlet of the grass filter strip. A mixing column of 295-mm diameter and roughly 2 m long was used to mix soil and water to prepare slurry. A high clay content soil was dried, ground and sieved using US Standard sieve no. 40 (425 μm). For each run a soil-slurry was prepared by mixing a selected mass (0.5, 1, 2 or 4 kg) of sieved soil with 40 L of clean water in the mixing column. A sump pump was used in the mixing column for continuous stirring of slurry during the experiment. To simulate upland runoff, the prepared slurry was mixed with the clean water and was delivered at the inlet of the filter strip at a set rate using peristaltic pumps into a 1.2-m wide spreading device (perforated PVC pipe) where it was first diluted and then well mixed with the steady-rate inflow of clear water at the weir box upstream of the plots.

The slurry-feeding rate was set between 0.5 to 2.0 L/min using an adjustable switch on the peristaltic pumps to ensure a steady supply of slurry for the desired duration of run which varied from 10 to 40 min. The duration of the run was selected to be at least three times the travel time for the plot to guarantee that the concentration of suspended sediments at the VFS outlet had reached a steady-state condition. Flow depth within the VFS was measured near the upstream edge, at mid-length and near the outlet of the strip and the travel time was determined as the ratio of volume of the resident water in the VFS to flow rate at inlet. The average depth of flow was between 15 and 50 mm and the average flow velocity ranged from 0.01 to 0.05 m/s, both increasing with the flow rate. The total suspended sediment concentrations at the VFS inflow ranged from 105 to 8525 mg/L, as shown in Table 1.

Sample Collection and Analysis

For a typical run, at all three sites, two 500-mL runoff samples were collected at the upstream end and two 500-mL runoff samples were collected at the downstream end of the filter strip. Standard analytical procedures were followed for the analysis of the samples. For the TSS concentration measurement, first the volume of the sample was measured and then the sample was filtered through a 0.45-μm filter, oven-dried at 105°C for 24 h and weighed.

Sediment Particle Size Distribution

To study the importance of inflow sediment particle size distribution on the sediment removal efficiency of VFS, runoff samples entering and leaving the VFS were tested using a particle size analyzer (Malvern Mastersizer). Seven sediment particle size ranges were selected: ($0.5 < d < 2.9$), ($2.9 < d < 6.4$), ($6.4 < d < 12$), ($12 < d < 39$), ($39 < d < 68$), ($68 < d < 151$) and ($151 < d < 492$); where d is the particle size in microns. The sediment removal efficiency was determined by comparison of sediment mass at the inlet and outlet of the VFS in each size range.

Contaminant Removal Efficiency

Since the runs were conducted under steady-state conditions, the "concentration-based" removal efficiency was calculated from the inflow and outflow TSS concentrations. The concentration-based removal efficiency is representative of the conditions in the early spring or late fall where infiltration is negligible. The total sediment load entering and leaving the VFS during the steady-state runs were calculated based on observed values of contaminant concentrations and associated flow rates at both VFS inlet and outlet. The "mass-based" contaminant removal efficiency was also calculated from the total mass of contaminants at inlet and outlet of the VFS that was, in general, slightly higher than the concentration-based removal efficiency due to the infiltration removal mechanism.

Results and Discussion

The objective of this study was to determine the effect of filter strip width, flow rate, grass type and inflow sediment characteristics on the effectiveness of the VFS in removing sediments from runoff. In total, 137 runs were completed between 1998 and 2004.

Statistical Analysis

The data are divided into three sets, one for each site. Full generalized linear models were analyzed including all main factors and various interaction effects. The models are then reduced to include only those factors and interactions which have a significant effect on the concentration-based removal efficiency. The experiment is modelled as an observational study since true replications are not included in the experiment, nor are each possible combination of factors. Aside from the grass type and the year of the study, the variables in each model are treated as covariates since they are recorded as continuous variables and contain the most information in this form. The level of significance used is the 10% level for conservatism. Once the final models were completed, the residuals were plotted against the normal distribution in a quantile plot to verify that the assumptions of the models hold. The residuals for each model were indeed found to be approximately normally distributed with a mean of zero and a constant variance, thus the models are deemed well fit.

Carol Creek Farm. The data taken from the Carol Creek Farm in 1998 included a sample size of 32 measurements. The data were taken from this site only in one year, thus the year is clearly not a factor in this

TABLE 2. Type III tests of fixed effects on the response variable of sediment removal efficiency for the Carol Creek Farm data

Source of variation	*D.F.*[a]	*Type III S.S.*[b]	*M.S.*[c]	*F-Value*	*p-Value*
Filter width	1	0.0163	0.0163	4.71	0.0406
Grass type	2	0.0255	0.0127	3.68	0.0410
Flow rate	1	0.0897	0.0897	25.93	<0.0001
(Flow rate) × (grass type)	2	0.0225	0.0112	3.25	0.0573
(Filter width) × (flow rate)	1	0.0123	0.0123	3.55	0.0721
(Filter width)^2	1	0.0167	0.0167	4.82	0.0385

[a]Degrees of freedom.
[b]Sum of squares.
[c]Mean square.

model. All of the factors in the model are treated as fixed and their type III tests are shown in Table 2.

The filter strip width follows a quadratic form, indicating curvature in the response variable of concentration-based removal efficiency due to this covariate. There are significant interactions between the filter strip width and the flow rate, as well as between the grass type and the flow rate. The main effects of filter strip width, grass type and flow rate are all also shown to be significant in modelling the concentration-based removal efficiency. Note that the sediment loads were found to be insignificant in this model. Two contrasts were also analyzed for this site. The first found that the grass type containing a mixture of Birdsfoot Frefoil and Creeping Red Fescue significantly increased the concentration-based removal efficiency in comparison to the average of the grass type containing an equal mixture of Perennial Ryegrass, Kentucky Bluegrass and Reed Canarygrass, and the grass type of existing native vegetation. The second contrast confirmed the same results when the flow rate was interacting with the various grass types.

Elora Research Farm. The data taken from the Elora Research Farm in 2003 and 2004 included a sample size of 33 measurements. Although the data were taken from this site in two years, only 6 measurements were taken in 2003 and so it was deemed appropriate to exclude this year from the analysis. Therefore, the year is again clearly not a factor in this model. All of the factors in the model are treated as fixed and their type III tests are shown in Table 3.

The factors of filter strip width and flow rate follow quadratic forms, as well as the interactions between these two covariates. This again indicates curvature in the concentration-based removal efficiency, however there is also a significant linear interaction between these two variables. All of the main effects in the model, the sediment loads, the flow rate, the grass types and the filter strip width were found to be significant factors in modelling the response of the concentration-based removal efficiency.

Guelph Turfgrass Institute. The data taken from the Guelph Turfgrass Institute in 2000 and 2002 included a sample size of 72 measurements. Here, both of the years in which the data were recorded contain valid measurements, thus the year is included as a factor in the model. This site, however, contained only one grass type, Peren-

TABLE 3. Type III tests of fixed effects on the response variable of sediment removal efficiency for the Elora Research Farm data

Source of variation	*D.F.*[a]	*Type III S.S.*[b]	*M.S.*[c]	*F-Value*	*p-Value*
Filter width	1	0.0034	0.00346	6.66	0.0209
Grass type	2	0.0134	0.0067	13.27	0.0005
Flow rate	1	0.0028	0.0028	5.51	0.0331
Inflow sediment concentration	1	0.0023	0.0023	25.21	0.0002
(Filter width) × (flow rate)	1	0.0027	0.0027	5.29	0.0362
(Filter width)^2 × (flow rate)	1	0.0023	0.0023	4.67	0.0473
(Filter width) × (flow rate)^2	1	0.0021	0.0021	4.09	0.0613
(Filter width)^2 × (flow rate)^2	1	0.0018	0.0018	3.48	0.0819
(Filter width)^2	1	0.0035	0.0035	6.90	0.0190
(Flow rate)^2	1	0.0023	0.0023	4.52	0.0506

[a]Degrees of freedom.
[b]Sum of squares.
[c]Mean square.

TABLE 4. Type III tests of fixed effects on the response variable of sediment removal efficiency for the Guelph Turfgrass Institute data

Source of variation	*D.F.*[a]	*Type III S.S.*[b]	*M.S.*[c]	*F-Value*	*p-Value*
Year	1	0.0160	0.0160	3.26	0.0755
Filter width	1	0.2406	0.2406	49.13	<0.0001
(Filter width)^2	1	0.0964	0.0964	19.67	<0.0001
Flow rate	1	0.0423	0.0423	8.63	0.0046
(Filter width) × (flow rate)	1	0.0212	0.0212	4.34	0.0413
(Flow rate)^2	1	0.0410	0.0410	8.36	0.0052

[a]Degrees of freedom.
[b]Sum of squares.
[c]Mean square.

nial Ryegrass, therefore the grass type is clearly not included as a factor in the model. Upon initial analysis of the data from the site, one outlying data point was found, was deemed invalid, and thus was removed from the data set. All of the factors in the model are treated as fixed and their type III tests are shown in Table 4.

Again, the flow rate and the filter strip width follow quadratic forms, indicating curvature in the concentration-based removal efficiency. There is also a significant linear interaction between these two covariates. The main effects of year, filter strip width and flow rate are also found to be significant in modelling the response variable of interest. Note that again the inflow sediment concentration was found to be an insignificant factor in this model.

Sediment Particle Size Distribution

Sediment particle size distribution is an important design consideration for the VFS. Figure 2 shows the average (for 58 runs in 2000 at the Guelph Turfgrass Institute site) sediment removal efficiency of VFS for six particle size ranges, including: (0.5 < d < 2.9), (2.9 < d < 6.4), (6.4 < d < 12), (12 < d < 39), (39 < d < 68) and (68 < d < 151), where d is the particle size in microns. It is evident from the data that the first five metres of filter strip play a large role in removal of suspended sediments. The mass percent removal efficiency of a 5-m plot for an average unit flow rate of 1 L/s for the six particle size ranges were: 62, 68, 64, 80, 95 and 97%, respectively.

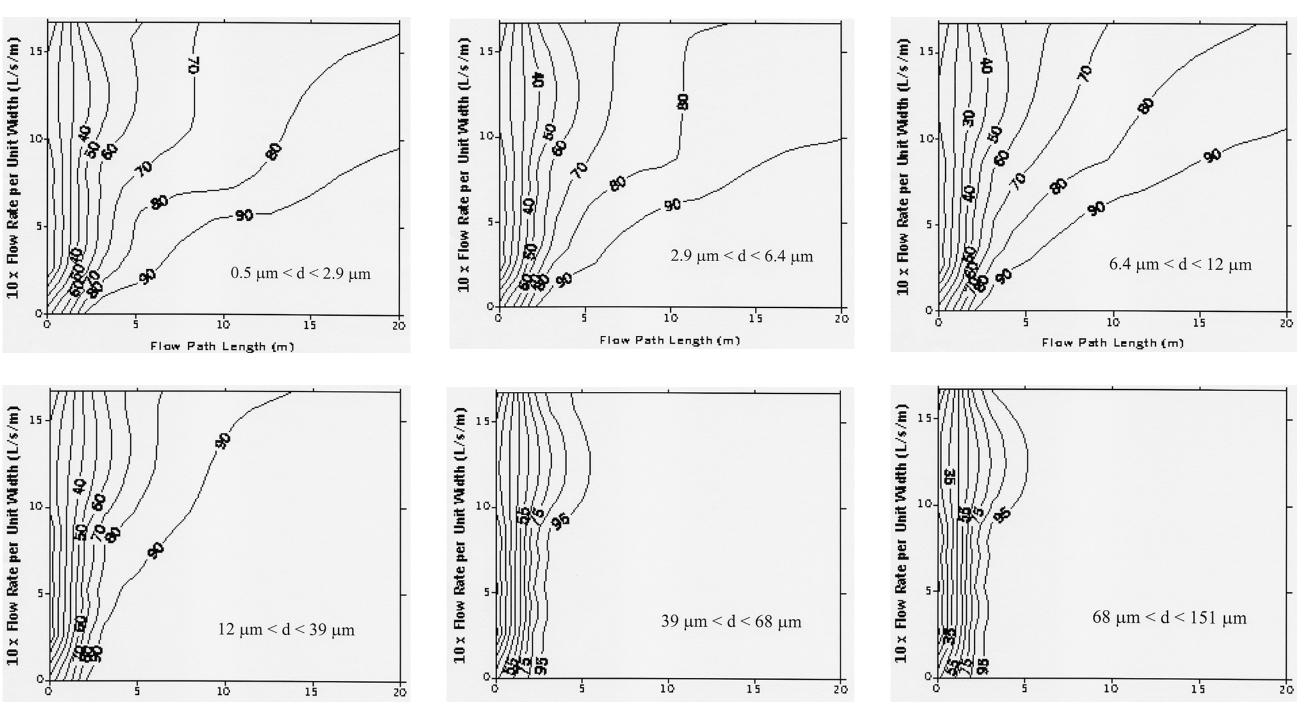


Fig. 2. Sediment mass percent removal efficiency (the isobars represent % removal) in VFS under different flow rates and flow path lengths for six aggregate size ranges, including: (0.5 < d < 2.9), (2.9 < d < 6.4), (6.4 < d < 12), (12 < d < 39), (39 < d < 68) and (68 < d < 151), where d is the particle size in microns. Based on analysis of 58 tests completed in 2000 at GTI site.

On average, about 50% of sediments were removed within the first 2.5 m of the filter flow path length (i.e., the 50% removal isobar is roughly crossing the 2.5 m plot length). An additional 25 to 45% (depending on flow rate) of sediments were removed within the next 2.5 m of the filter flow path length. Almost all of the easily removable aggregates, aggregates larger than 40-μm (P_{50}) in diameter, were captured within the first five metres of filter strip flow path. However, the remaining small-size aggregates were not easily removed as relatively low turbulent energy in the water was sufficient to keep the sediments in suspension.

Overall, this study indicates that the width of the filter strip, grass type, flow rate and inflow sediment particle size distribution are significant factors influencing sediment removal efficiency of the VFS. Other researchers, including Dillaha et al. (1989), Daniels and Gilliam (1996), Robinson et al. (1996), Schmitt et al. (1999) and Abu-Zreig et al. (2003) have also observed similar results for VFS that strengthen these findings.

Conclusions

This study indicates that VFS are very effective in reducing the concentration of total suspended sediments and sediment-bound contaminants in runoff. In general, sediment removal efficiency of a VFS is a function of filter strip width, grass type, flow rate and sediment characteristics. Denser vegetation and longer filter strips, generally, were found to be more efficient in the trapping of different pollutants. This study indicates that the first five (5) metres of a filter strip are critical and effective in removal of suspended sediments. More than 95% of the aggregates larger than 40 μm in diameter can be captured within the first five metres of the filter strip. However, the remaining smaller size (<40 μm) aggregates are very difficult to remove by filtering through grass, as even relatively low levels of turbulent energy in the water are sufficient for keeping the finer sediments in suspension.

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Table 3.1: Hydrologic Cycle Component Values

	Water Holding Capacity mm	Hydrologic Soil Group	Precipitation mm	Evapo-transpiration mm	Runoff mm	Infiltration* mm
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)						
Fine Sand	50	A	940	515	149	276
Fine Sandy Loam	75	B	940	525	187	228
Silt Loam	125	C	940	536	222	182
Clay Loam	100	CD	940	531	245	164
Clay	75	D	940	525	270	145
Moderately Rooted Crops (corn and cereal grains)						
Fine Sand	75	A	940	525	125	291
Fine Sandy Loam	150	B	940	539	160	241
Silt Loam	200	C	940	543	199	199
Clay Loam	200	CD	940	543	218	179
Clay	150	D	940	539	241	160
Pasture and Shrubs						
Fine Sand	100	A	940	531	102	307
Fine Sandy Loam	150	B	940	539	140	261
Silt Loam	250	C	940	546	177	217
Clay Loam	250	CD	940	546	197	197
Clay	200	D	940	543	218	179
Mature Forests						
Fine Sand	250	A	940	546	79	315
Fine Sandy Loam	300	B	940	548	118	274
Silt Loam	400	C	940	550	156	234
Clay Loam	400	CD	940	550	176	215
Clay	350	D	940	549	196	196

Notes: Hydrologic Soil Group A represents soils with low runoff potential and Soil Group D represents soils with high runoff potential. The evapotranspiration values are for mature vegetation. Streamflow is composed of baseflow and runoff.

* *This is the total infiltration of which some discharges back to the stream as base flow. The infiltration factor is determined by summing a factor for topography, soils and cover.*

Topography	Flat Land, average slope < 0.6 m/km	0.3
	Rolling Land, average slope 2.8 m to 3.8 m/km	0.2
	Hilly Land, average slope 28 m to 47 m/km	0.1
Soils	Tight impervious clay	0.1
	Medium combinations of clay and loam	0.2
	Open Sandy loam	0.4
Cover	Cultivated Land	0.1
	Woodland	0.2

Winter Operation

In general, infiltration facilities are unsuitable for water quality treatment during the winter/ spring period. They are subject to reductions in capacity due to freezing or saturation of the soil. If road runoff is received, there is an increased likelihood of clogging due to high sediment loads and an increased risk of groundwater contamination from road salt.

If infiltration practices are used as an all-season water quality treatment facility, then doubling the design storage volume for surface infiltration devices to account for reduced infiltration rates is recommended. Redundant pre-treatment (more than one pre-treatment device in series) is recommended for all infiltration facilities receiving road runoff. A pre-treatment volume of about 15 mm/impervious hectare is recommended.

Technical Effectiveness

Centralized infiltration trenches have a poor historical record of success (Lindsey et al., 1992; Metropolitan Washington Council of Governments, 1992). This lack of success is attributable to many factors:

- poor site selection (industrial/commercial land use, high water table depth, poor soil type);
- poor design (lack of pre-treatment, clogging by native material);
- poor construction techniques (smearing, over-compaction, trench operation during construction period); and
- large drainage area (high sediment loadings, groundwater mounding).

There are many reasons why an infiltration trench can fail. One of the main problems with centralized infiltration trenches is that water from a large area is expected to infiltrate into a relatively small area. This does not reflect the natural hydrologic cycle and generally leads to problems (groundwater mounding, clogging, compaction).

Water quality enhancement can be achieved using infiltration trenches. However, care must be taken to avoid degradation of groundwater quality. Trenches are ineffective quantity control facilities unless substantial storage is provided and the soil conditions are optimum.

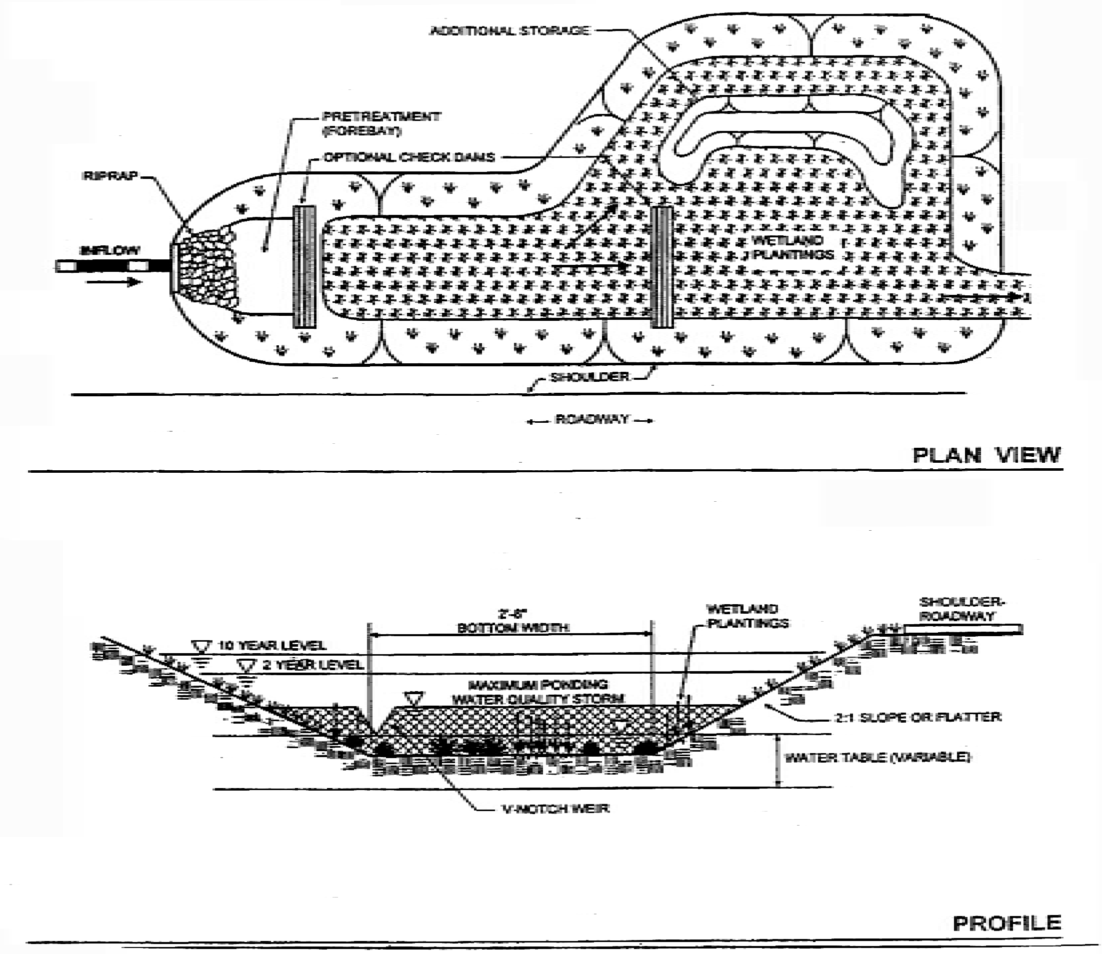
4.5.9 Grassed Swales

Grassed swales have historically been associated with rural drainage and have been constructed primarily for stormwater conveyance. Stormwater management objectives have changed and grassed swales are now being promoted to filter and detain stormwater runoff. Swale drainage can be a useful technique in areas of low grade, as long as the distance that the flow is to be conveyed is not too long.

The majority of swale systems in Ontario have been designed as “dry” swales. The guidance provided below is for such systems. An alternate design, the “wet” swale, can also be useful in areas where there is sufficient space, especially where soils are not highly permeable, or where there are low lying areas with a high water table.

Wet swales combine elements of dry swale systems and wetland systems. Wet swales are typically wider than dry swales (e.g., 4 m - 6 m) and the check dams are used to create shallow impoundments in which wetland vegetation is planted or allowed to colonize. Because of their width, wet swales are not generally implemented along the front of residential properties, but rather are included where overland flow routes use linear open space areas. Combined systems of dry and wet ponds may be used. Wet swales have been implemented in several highway projects, but monitoring results are limited. A schematic of a wet swale is provided in Figure 4.9.

Figure 4.9: Schematic of a Wet Swale



Wet swales are ideal for treating highway runoff in low lying or flat terrain areas.

Source: Maryland Stormwater Manual, Volume 1, 1998.

Design Guidance

<u>Swale Cross-section</u>

Grassed swales can be effective SWMPs for pollutant removal if designed properly. The water quality benefits associated with grassed swales depend on the contact area between the water and the swale and the swale slope. Deep narrow swales are less effective for pollutant removal compared to shallow wide swales. Given typical urban swale dimensions (0.75 m bottom width, 2.5:1 side slopes and 0.5 m depth), the contributing drainage area is generally limited to ≤ 2 ha (to maintain flow ≤ 0.15 m^3/s and velocity ≤ 0.5 m/s). Table 4.5 indicates drainage area restrictions for various degrees of imperviousness, based on the assumptions given regarding channel cross-section, slope and cover. The swales evaluated in Table 4.5 are indicative of swales servicing an urban subdivision and not a transportation corridor.

Table 4.5: Grassed Swale Drainage Area Guidelines*

% Imperviousness	Maximum Drainage Area (ha)
35	2.0
75	1.5
90	1.0

* *Based on the following assumptions: trapezoidal channel, grassed lined (n = 0.035), slope of drainage area = 2%, 2.5:1 side slopes, 0.75 m bottom width, 0.5% channel slope, max. allowable Q = 0.15 m^3/s, max. allowable V = 0.5 m/s.*

Grassed swales are most effective for stormwater treatment when depth of flow is minimized, bottom width is maximized (≥ 0.75 m) and channel slope is minimized (e.g., ≤ 1%). Grassed swales with a slope up to 4% can be used for water quality purposes, but effectiveness diminishes as velocity increases. Grass should be allowed to grow higher than 75 mm to enhance the filtration of suspended solids.

<u>Flow Velocity</u>

As a general guideline, grassed swales designed for water quality enhancement should be designed to convey the peak flow from a 4 hour 25 mm Chicago storm with a velocity ≤ 0.5 m/s. This guideline results in a requirement for wide, flat swales for larger drainage areas.

All grass swales must be evaluated under major system and minor system events to ensure that the swale can convey these storms effectively.

<u>Ditch and Culvert Servicing</u>

Ditch and culvert servicing is viable for lots which will accommodate swale lengths ≥ the culvert length underneath the driveway (not just the driveway pavement width). The swale length should also be ≥ 5 m for aesthetic and maintenance purposes. This is generally achievable for small lots (9 m) with single driveways or larger lots (15 m) with double driveways.

<u>Winter Operation</u>

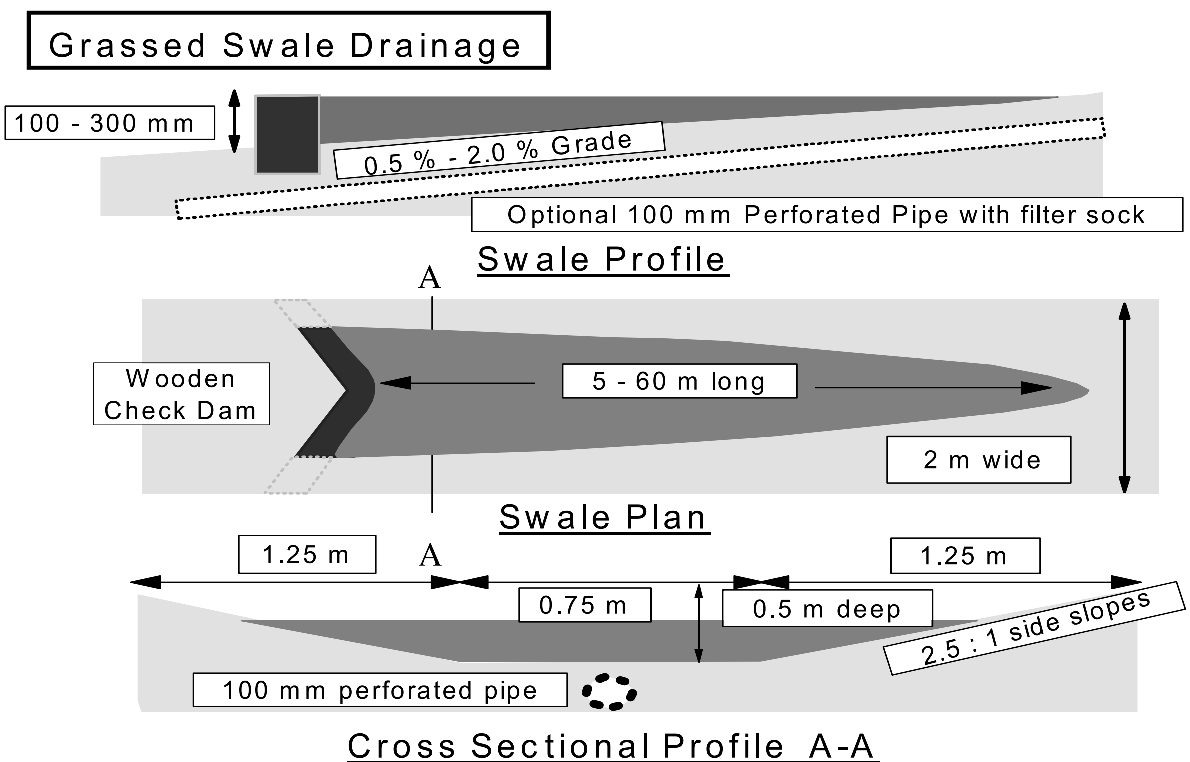
Swale systems which receive road runoff may have their infiltration capacity diminished over time, as salt effects on soil structure and clogging occur. Swale systems need to be maintained periodically (removal of accumulated sand and addition of mulch to the soil structure) in order to maintain their ability to infiltrate.

Relatively few design modifications are warranted for swales in cold climates, primarily due to their inherent simplicity. The following design modifications will tend to enhance their performance:

- Culverts should have a minimum diameter of 450 mm and a slope of 1% or greater; and
- For swale systems with an underdrain system, the underdrain should have a minimum diameter of 200 mm and should be bedded in gravel.

Performance Enhancements
In order to promote infiltration of stormwater and the settling of pollutants, permanent check dams can be constructed at intervals along the swale system. These enhancements are best utilized on large swales where the cumulative flow depth and rate is not conducive to water quality enhancement ($V \geq 0.5$ m/s or $Q \geq 0.15$ m³/s during the 25 mm 4 hour storm). The distance between check dams can be calculated based on the depth of water at the check dam and the swale channel slope. For example, if a swale has a 1% slope and a check dam height of 0.3 m, the distance between check dams should be 30 metres (or less). Figure 4.10 illustrates an enhanced grassed swale design.

Figure 4.10: Enhanced Grass Swale



The dam should be constructed out of durable material (wood) which blends into the surrounding landscape. A rock check dam can be used if the swale is located in a remote area which is not subject to vandalism. The dam should be configured in a V shape to help minimize scour and erosion of the downstream swale banks (V points upstream). The dam should be securely embedded in the swale banks and some rip-rap should be placed downstream of the dam to prevent scour and erosion. The velocity of the design conveyance storm should be kept to approximately 1 m/s whereby smaller stone sizes can be utilized (75 mm diameter).

In areas where the swales are separated by driveway culverts, the culverts can be raised such that the driveway embankment (up to the invert of the driveway culvert) acts as the check dam. This design is more aesthetically appealing and negates the need for rip-rap erosion protection. The driveway culvert should be underdrained, however, to ensure that a permanent pool of water is not created in the swale.

A low flow opening can be created in the check dam to ensure a drawdown time ≤ 24 hours. However, recognizing the potential for clogging of the low flow opening, it is recommended that swales with check dams be underdrained in soils with poor infiltration potential (e.g., clays).

Standard 100 mm perforated pipe (or larger) should be used in combination with a filter sock in any type of underdrain system. Stone storage can be provided around perforated pipes that are installed under swales as a secondary storage medium to promote exfiltration. The appropriate depth of soil cover for the stone storage should be based on the surrounding soil conditions and the potential for frost heave. Figure 4.4 indicates the recommended soil cover based on the native soil type and trench depth.

All grass swales must be evaluated under major system and minor system events neglecting the storage/conveyance below the overflow of any check dam to ensure that the swale can convey these storms effectively.

Technical Effectiveness

The effectiveness of swale systems is highly dependent on their design and maintenance. It is therefore recommended that they be used as part of a multi-component approach (i.e., one measure in a series of stormwater quality measures). They may be used for pre-treatment or polishing.