5.0 Stormwater Management

5.1 BACKGROUND

The Chinook Ridge Golf Course and Lodge Stormwater Management Plan was conducted by Stantec Consulting Ltd. to identify stormwater servicing requirements for the proposed 60.3 ha golf course and lodge development east of Highway 22 and north of Highway 574 in Rocky View County, about 12 km southeast of Cremona, Alberta (approximately 30 minutes NW of Calgary and 30 minutes NE of Cochrane). The lodge will operate year round while the golf course will operate during the summer months.

5.2 OBJECTIVES

The purpose of the stormwater management plan is to provide a conceptual design of the stormwater servicing requirements for the proposed Chinook Ridge development to support the regulatory approvals requirements under the Water Act administered by Alberta Environment. The specific objectives are:

- Calculate stormwater runoff volumes for the existing condition (pre-development) and for the anticipated post-development condition
- Identify stormwater best management practices (BMPs) that are suitable for the site
- Discuss the regulatory approval requirements for stormwater facilities
- Provide recommendations on a stormwater management system design, that embodies relevant aspects from Alberta Environment's Low Impact Development (LID) strategies
- Prepare a stormwater management report for regulatory approval under the Water Act

5.3 SITE DESCRIPTION

5.3.1 Location

The proposed golf course and lodge development boundary is shown on **Figure 5.1** and comprises approximately 60.3 ha. The study area is located east of highway 22 and north of highway 574, about 12 km southeast of Cremona, Alberta. The site incorporates most of the quarter section at SE¼-Sec31-Twp28-Rge3-W5 with the exception of about 4.1 ha in the northeast corner, which belongs to another landowner.

Note that the current design (formerly known as the Hummingbird Golf Club Conceptual Master Plan by Rod Whitman Golf Course Design Ltd.), shows this separate parcel to be approximately 2.2 ha. However, for the purpose of this stormwater management plan, it is assumed that the legal land boundaries provided by Rocky View County are accurate, and that the separate parcel is 4.1 ha. The study site boundary around the separate parcel should be confirmed.

5.3.2 Existing Geotechnical Conditions

Based on the well bore data obtained during the Groundwater Evaluation – Chinook Ridge Lodge and Golf Course, SE-31-28-3-W.5 (Stantec Consulting, 2010), the surface soil at the site contains mainly clay till to a depth of about 8 m, which overlies layers of shale, siltstone and sandstone. The underlying aquifer is confined by about 9 m of low permeability clay and shale.

5.3.3 Existing Land Use

The study area is currently undeveloped and is used for agricultural purposes. A residence with gravel road access and a barn are currently located near the southeast corner of the site. A small forested section is located near the middle of the site.

5.4 PROPOSED LAND USE

The study area will primarily be used for an 18 hole golf course, which will operate during the summer months. There will be approximately 15 cabins and 15 RV stalls and a lodge on the development that will operate year round. There will be a parking lot in the southeast corner of the site, which is assumed to be gravel at first and paved within the first few years of opening. Although some site grading is likely necessary during construction of the golf course, cabins, lodge and parking lot, it is assumed that this will not significantly alter the overall topography and drainage basins/routes of the site.

5.5 GENERAL

This section outlines the conceptual design of the stormwater management system for the proposed golf course and lodge. Components that were considered during the design include county and provincial design criteria, regulatory requirements, hydrologic analyses, best management practices and low impact development (LID) strategies.

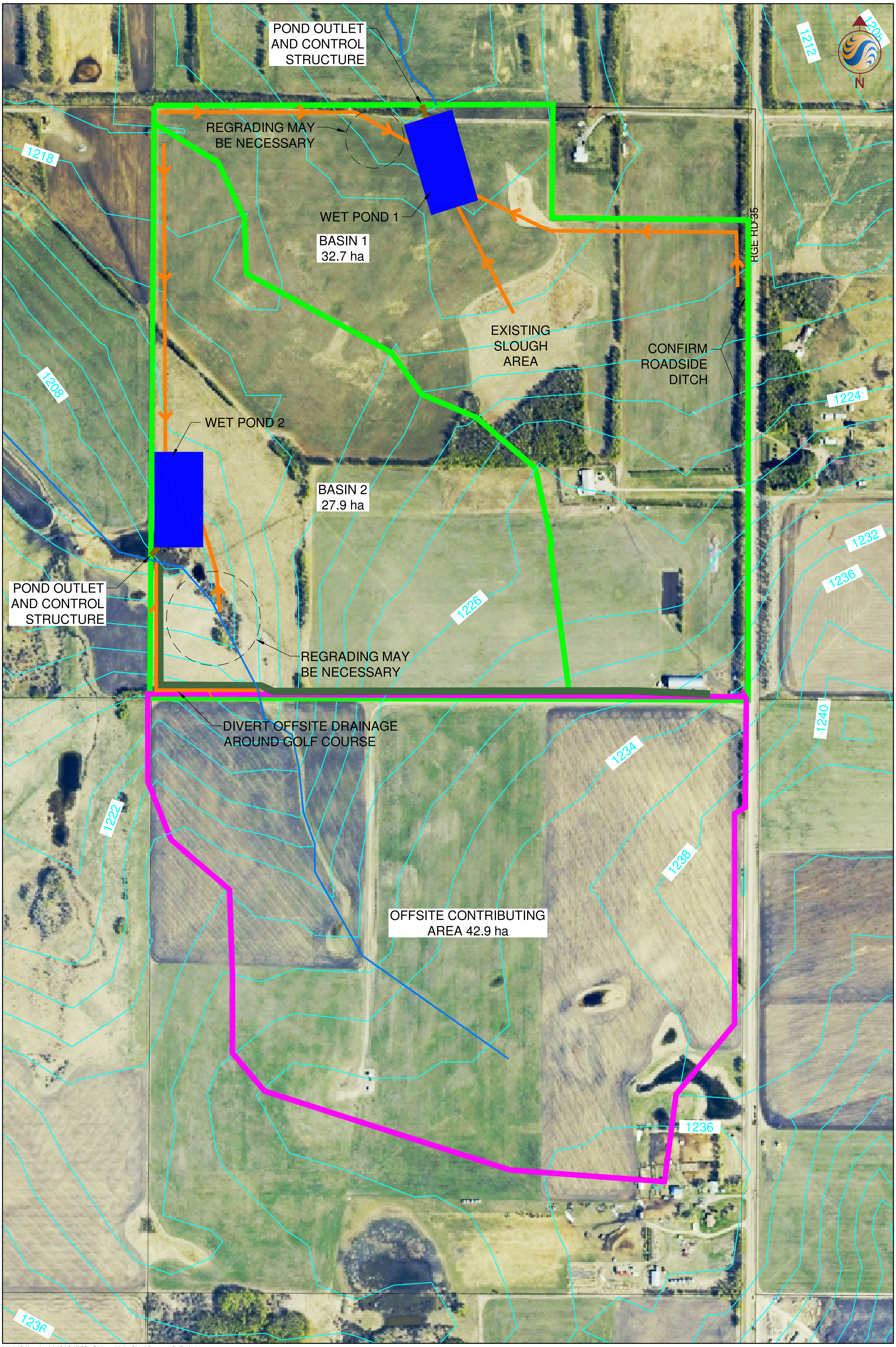
As a result of the proposed development, a slight increase in runoff volume and peak flow may occur, mainly due to the construction of impervious or lower pervious surfaces related to the cabins, lodge, and parking lot. However, the storm runoff can be collected on site and used for golf course irrigation during periods of dry weather. In terms of runoff quality, the primary concerns are fertilizers used on the golf course and salt used for deicing the parking lot and walkways surrounding the lodge and cabins. Erosion and resulting suspended solids in runoff are likely to be less after the proposed development compared to the existing agricultural land use because the soil on the site will no longer be routinely disturbed by plowing and other agricultural activities, and will instead be covered with grass. Both stormwater quantity and quality are discussed in the following sections as they relate to the stormwater management system design.

5.6 EXISTING DRAINAGE AND TOPOGRAPHY

The study area boundary is shown on **Figure 5.1**. The total gross study area is 60.3 ha. **Figure 5.1** shows the existing topography at 2 m contour intervals and the natural drainage pattern within the study area. The site is located near the eastern edge of the foothills of the Rocky Mountains, and can be considered “gently undulating” in nature (Shetsen, 1990). In general, the site slopes downward from the southeast to the northwest, with a low ridge running from approximately the southeast corner to the northwest corner, splitting the site into two distinct basins, as indicated on **Figure 5.1**. The east basin (Basin 1) is approximately 32.7 ha while the west basin (Basin 2) is approximately 27.9 ha. Both basins drain through normally dry channels towards the north-northwest, and these channels lead to Dog pound Creek that lies approximately 6 km northwest of the site. Dog pound Creek is a tributary of the Red Deer River. Basin 1 contains a relatively flat, poorly drained slough area while Basin 2 contains a well-defined drainage channel (shown on **Figure 5.1**) leading towards Dog pound Creek.

The highest existing land elevation on the site is 1,234 m located at the southeast corner. The lowest land elevation is 1,208 m located on the west boundary of the site in the drainage channel leading towards Dog pound Creek. The aforementioned ridge runs from the 1,234 m high point in the southeast corner to the northwest corner of the site where the elevation is 1,218 m.

There is an area of approximately 42.9 ha that lies south of the proposed development that drains stormwater runoff through the study site. Most of this runoff flows towards the drainage channel that passes through the southwest corner of the site. Although approximately 5.2 ha to the southeast of the site (east of Range Road 35) drains towards the site, it is assumed that the runoff from this area is collected in a drainage ditch to the east of Range Road 35, and will not enter the study site.



V:\1101\active\149104750_Chinook\drafting\figures\fig5_1.dwg
2011-08-15 12:21PM By: lgrebaz

August, 2011
1491-04750/400

Legend

- ONSITE BASIN
- OFFSITE CONTRIBUTING AREA
- GRASS SWALES AND FLOW DIRECTION
- EARTHEN BERM
- WET POND LOCATION
- 1238 CONTOUR INTERVALS (2m)
- NATURAL DRAINAGE CHANNEL

Scale

0 50 150 250m

1:5,000

Stantec

Client/Project

CHINOOK RIDGE LODGE AND GOLF COURSE LTD.

INTEGRATED WATER MANAGEMENT PLAN

Figure No.

5.1

Title

Stormwater Management
Conceptual Design

5.7 DESIGN CRITERIA AND REGULATORY REQUIREMENTS

The design criteria in the Rocky View County Servicing Standards (June 1999) were incorporated into the conceptual design of the stormwater management system for the proposed development. A summary of the design criteria applicable to this study are as follows:

- Post development runoff to adjacent lands must not be greater than the predevelopment runoff quantities
- Post development runoff to adjacent lands will be of the highest quality possible
- Best management technical practices should be used to quantify and qualify stormwater runoff
- The maintenance of the stormwater management system should accommodate the rural context of the Municipality
- Surface runoff conveyance systems and retention facilities must be designed to accommodate runoff from a storm event with a 100 year return period

Alberta Environment Stormwater Management Guidelines (January 1999) were also consulted during the conceptual design process, and highlight several best management practices for stormwater management systems. Best management practices relevant to the Chinook Ridge Lodge and Golf Course have been accommodated in the stormwater management plan.

The proposed stormwater management facilities will be located on private land and will be operated by the owner.

5.8 HYDROLOGIC ANALYSIS

This section provides the hydrologic analysis results for the existing condition and for the proposed development of a golf course and lodge.

Based on the existing topography and the proposed development, the study area was divided into three main catchments as shown on **Figure 5.1**. Two catchment areas are located on the study site, while the third represents an offsite catchment area that contributes runoff to the site via overland flow. A hydrologic analysis was carried out using the EPA SWMM Runoff block for existing and future development conditions to determine the peak flows and runoff volumes using the hydrologic parameters summarized in **Table 5.1.**

The recommended range for each hydrologic parameter based on the soil conditions (clay with silt, sand and gravel deposits) and land use of the study site, according to the EPA SWMM user manual, were used as a basis in selecting the hydrologic parameters. These parameters were then modified slightly to obtain runoff coefficients (ratio of runoff to rainfall) that are roughly consistent with the typical runoff coefficients found in Table 4-4 in the Alberta Environment Stormwater Management Guidelines (1999). These guidelines suggest that the ratio of runoff to rainfall should be approximately 0.40 for undeveloped land with clayey soil and 0.60 for parks (assumed to be similar to a golf course) for a 1:100 year rainfall event. The suggested runoff coefficient for both undeveloped land and parks is near 0.10 for a 1:5 year rainfall event.

The Curve Number (CN) method for determining runoff rates and volumes was also considered for this study. However, use of this method is very sensitive to the CN that is selected for each land use. In the case of the pre-development CN, there is a wide range of values that can be used for agricultural land, and it was found that in some cases, the post-development runoff was less than the pre-development runoff using the CN method. Therefore, in order to be conservative in predicting post-development runoff, the Horton's Infiltration method was used, which requires specification of the initial and final (saturated) infiltration rates and a decay constant, which are functions of the soil type.

Table 5.1
Hydrologic Parameters

Description	Pre-Development	Post-Development
Infiltration Parameters		
Initial Infiltration Rate (mm/hr)	75	75
Final Infiltration Rate (mm/hr)	1.75	1.75
Decay (1/s)	0.00115	0.00115
Manning's "n" Values		
Pervious Area	0.25	0.10
Impervious Area	0.013	0.013
Depression Storage		
Impervious Area (mm)	1.6	1.6
Pervious Area (mm)	6.4	2.5
Basin Characteristics		
Imperviousness (%)	5	15
Catchment Length/Width Ratio	Determined based on catchment shape	
Ground Slope (%)	Determined based on topography	

Several hydrologic parameters were modified slightly for the post-development condition, to account for the change in land use from agriculture to a golf course and lodge. These changes include:

- The imperviousness of the pre-development is estimated at 5%, because most of the site is used for agricultural purposes. The imperviousness of the post-development is assumed to be 15%, based on improved drainage, increase in roof area (cabins and lodge) and construction of a parking lot and pathways winding through the golf course.

- The pervious area Manning "N" value is assumed to change from 0.25 in the pre-development condition to 0.10 in the post-development condition to account for the smoother surface of the golf course compared to the existing cultivated field.

- The pervious area depression storage is assumed to drop from 6.4 mm in the pre-development condition to 2.5 mm in the post-development condition to account for the smoother surface of the golf course compared to the existing cultivated field, which results in less surface storage capacity in the post-development condition.

- Other hydrologic parameters are assumed to remain relatively constant from pre to post-development.

The simulated peak flows and runoff volumes for the 5, 25 and 100 year 4 hour (Chicago Distribution) and 100 year 24 hour (HUFF distribution) design rainfall events are summarized in **Tables 5.2 and 5.3** for the existing and proposed development conditions, respectively. Rainfall hyetographs from Environment Canada for the Calgary Airport were used, as the Calgary Airport is the closest place that has published IDF curves.

Table 5.2
Summary of Hydrologic Analysis for Existing Conditions

Rainfall Event	Rainfall Depth (mm)	Runoff Volume (m^3)	Runoff Coefficient (Runoff/Rainfall)	Peak Flow (m^3/s)
Basin 1 (Area = 32.7 ha, Percent Imperviousness = 5%, Slope = 2.5%, Width = 379 m)				
5 Year - 4 Hour	29.2	460	0.048	0.24
25 Year - 4 Hour	41.3	1,920	0.143	0.36
100 Year - 4 Hour	51.3	4,260	0.254	0.49
100 Year - 24 Hour	95.3	12,100	0.388	0.41
Basin 2 (Area = 27.9 ha, Percent Imperviousness = 5%, Slope = 3.6%, Width = 581 m)				
5 Year - 4 Hour	29.2	390	0.048	0.21
25 Year - 4 Hour	41.3	2,160	0.187	0.31
100 Year - 4 Hour	51.3	4,520	0.316	0.47
100 Year - 24 Hour	95.3	11,090	0.417	0.47
Offsite Contrib. Area (Area = 42.9 ha, Percent Imperviousness = 5%, Slope = 2.9%, Width = 551 m)				
5 Year - 4 Hour	29.2	600	0.048	0.32
25 Year - 4 Hour	41.3	2,700	0.153	0.47
100 Year - 4 Hour	51.3	5,920	0.269	0.65
100 Year - 24 Hour	95.3	16,200	0.396	0.58

Table 5.3
Summary of Hydrologic Analysis for Post Development Conditions

Rainfall Event	Rainfall Depth (mm)	Runoff Volume (m^3)	Runoff Coefficient (Runoff/Rainfall)	Peak Flow (m^3/s)
Basin 1 (Area = 32.7 ha, Percent Imperviousness = 15%, Slope = 2.5%, Width = 379 m)				
5 Year - 4 Hour	29.2	1,680	0.176	0.68
25 Year - 4 Hour	41.3	4,800	0.356	1.12
100 Year - 4 Hour	51.3	7,780	0.464	1.55
100 Year - 24 Hour	95.3	16,120	0.517	0.69
Basin 2 (Area = 27.9 ha, Percent Imperviousness = 15%, Slope = 3.6%, Width = 581 m)				
5 Year - 4 Hour	29.2	1,590	0.195	0.62
25 Year - 4 Hour	41.3	4,600	0.399	1.10
100 Year - 4 Hour	51.3	7,270	0.507	1.62
100 Year - 24 Hour	95.3	14,060	0.529	0.71
Offsite Contrib. Area (Area = 42.9 ha, Percent Imperviousness = 5%, Slope = 2.9%, Width = 551 m) Note: Not changed from existing conditions				
5 Year - 4 Hour	29.2	600	0.048	0.32
25 Year - 4 Hour	41.3	2,700	0.153	0.47
100 Year - 4 Hour	51.3	5,920	0.269	0.65
100 Year - 24 Hour	95.3	16,200	0.396	0.58

The hydrologic analysis results indicate that the volume of runoff on the study site is increased by 30% during the 1:100 year 24 hour rainfall event as a result of the development of a golf course and lodge, from a total of 23,190 m^3 (Basins 1 and 2) in the existing condition to 30,180 m^3 in the post-development condition. During the short duration and higher intensity 1:100 year 4 hour event, the increase in runoff volume is 71%, from 8,780 m^3 to 15,050 m^3 (Basins 1 and 2). The peak runoff rate is also increased in the post development scenario, and this increase is more significant during the short duration higher intensity (i.e. 4 hour) events. The increase in peak runoff rate is over three-fold during the 1:100 year 4 hour event for basins 1 and 2. The increase in runoff volume and peak flow rate is primarily a result of the increased imperviousness, and to a lesser extent due to the decrease in surface storage caused by the development of the lodge and golf course.

The increase in runoff volume and peak flow could cause increased erosion on the downstream land and drainage channels. In order to minimize the impact of higher runoff volumes and peak flows on the downstream land, appropriate stormwater management measures must be implemented with the development of the golf course and lodge. The proposed stormwater management measures are outlined in **Section 5.11**.

5.9 REQUIRED POND STORAGE VOLUMES

Wet ponds are proposed in Basins 1 and 2 to store storm runoff for use in golf course irrigation. These wet ponds will also act as stormwater management facilities, where stormwater from significant rainfall events will be collected and released at a controlled rate, in order to dampen the peak flow rates from high intensity rainfall events. The required volume of the detention zone in each pond (i.e. the volume above the normal water level) was determined based on the volume of runoff from the 1:100 year 24 hour storm. Both the Rocky View County Servicing Standards and Alberta Environment Stormwater Management Guidelines require stormwater management facilities, such as wet ponds, to be sized for a 1:100 year rainfall event. Because each pond will be equipped with an outlet control structure that will release the storm runoff at a controlled (and relatively constant) rate during the rainfall, the release rate was subtracted from the simulated hydrograph (runoff rate versus time) from each basin to determine the net rate of accumulation of runoff in each pond. The net rate of accumulation of runoff in each pond was then summed up over the course of the rainfall event to determine the required storage volume of each pond. **Table 5.4** summarizes the required storage volumes in each pond. The required pond volumes in **Table 5.4** are for the onsite drainage only, and do not account for runoff generated offsite (i.e. south of the study site) that could flow onto the study site.

The pond outlet release rate was chosen to be equal to the peak runoff from the 1:5 year 4 hour rainfall event in the pre-development conditions. By doing so, the peak runoff in the post development condition will not exceed the pre-development runoff rate during intense storm events, which meets the requirements of the Rocky View County Servicing Standards. This also follows the low impact development (LID) principles in that the downstream land and watercourses will be protected from the increased runoff caused by the proposed development on the study site.

Table 5.4
Required Pond Storage Volumes

Basin	Total Post Development Runoff Volume during 1:100 Year 24 Hour Rainfall (m^3)	Pond Release Rate[A] (m^3/s)	Required Pond Storage Volume[B] (m^3)
Basin 1	16,120	0.24	6,070
Basin 2	14,060	0.21	5,920
Total	30,180	-	11,990

Notes:
A – Pond release rate to be controlled using outlet control structure (refer to **Section .5.11**), and is equal to the peak runoff rate from the 1:5 year 4 hour rainfall event in the existing (pre-development) condition.
B – Required volume of the active detention zone only, and does not include the volume of the permanent pool or freeboard. Refer to **Section 5.11** for the conceptual pond design.

5.10 PROPOSED STORMWATER MANAGEMENT SYSTEM

This section provides details of the conceptual stormwater management system that is proposed for the Chinook Ridge Lodge and Golf Course. The proposed storm drainage system primarily uses the natural topography (which should not be altered significantly during construction of the golf course and lodge), as well as a series of constructed swales, to convey surface runoff to two wet ponds. There is one wet pond located in each of the basins on the study site, and each is located at or near the point of lowest elevation in order to maintain the natural drainage pattern to the greatest extent possible. The objective of the stormwater drainage system is to reduce the impacts of the proposed development on the downstream land and watercourses by:

- Preventing the increased peak runoff rates and runoff volumes caused by the proposed development from causing increased erosion in downstream lands and drainage paths
- Minimizing the release of contaminants (resulting from fertilizers, pesticides and other potential contaminant sources involved with the proposed development) to downstream lands and watercourses by employing relevant best management practices
- Provide the opportunity for stormwater reuse that will reduce or eliminate the need to withdraw groundwater for irrigation purposes.

Each of these objectives is aimed at minimizing the impact of the development on the study site and surrounding lands, and in this way the proposed stormwater management system embodies the principles of LID. The proposed stormwater management system is described in detail in the following subsections, and was proposed under the following assumptions:

- Storm runoff cannot cross Range Road 35 to the east of the study site due to typical roadside ditches. The presence and condition of the roadside ditches should be confirmed.
- The study site boundary is the one indicated by the legal property line data supplied by Rocky View County.
- The natural topography and drainage pattern will not be altered significantly during construction of the lodge and golf course.
- Greens and tee boxes will require daily irrigation, but fairways will not require regular irrigation.

5.10.1 Basin 1 Drainage

Basin 1 is located on the eastern side of the proposed development, and generally drains from south to north. A natural drainage channel north of Basin 1 collects runoff from Basin 1 and conveys it towards Dog Pound Creek, about 6 km to the north. Basin 1 also contains a relatively flat and poorly drained slough, as indicated on **Figure 5.1.** The proposed drainage system in Basin 1 comprises mainly of the natural overland drainage, with several grass swales to direct runoff to the proposed wet pond located at the lowest point within Basin 1, at the north end of the study site. The location of the proposed wet pond and swales are shown on **Figure 5.1.** Swales are required along the north side of the site, to prevent runoff from exiting the site uncontrolled, and instead direct runoff to the wet pond for storage, treatment and release at a controlled rate. A swale or other drainage enhancement measure may also be required to enhance the drainage in the poorly drained slough located in the middle of Basin 1. Some re-grading near the proposed wet pond may be required so that all runoff from Basin 1 is directed to the wet pond; the area potentially requiring re-grading is identified on **Figure 5.1.**

The wet pond has been shown as a rectangular pond on **Figure 5.1;** however, the exact pond shape can be determined during detailed design, and could be incorporated into the golf course design. As shown in **Table 5.4**, the wet pond in Basin 1 must have an active storage volume of about 6,070 m^3 to accommodate runoff from the 1:100 year 24 hour rainfall event. The pond will discharge at a controlled rate of 0.24 m^3/s during severe rainfall events via an outlet structure and pipe to the drainage channel running north from the study site towards Dog Pound Creek. The pond and outlet structure will be designed so that the outlet pipe is contained on the study site, and discharges to the existing drainage channel to the north. During more frequent and less severe rainfall events, it is expected that the wet pond will store most or all runoff (depending on the water level in the pond and the intensity of the rainfall event) to be used for golf course irrigation. More details on the wet pond, outlet structure and outlet pipe are found in **Section 5.11.5**.

It is assumed that a drainage ditch is present along the western side of Range Road 35 (located on the eastern boundary of the study site) that will direct runoff from Basin 1 to the north and towards the proposed swale leading to the wet pond. However, the location and condition of the drainage ditch should be confirmed during detailed design.

The proposed parking lot to be located in the southeast corner of Basin 1 should drain via overland flow to the north where it will be collected by the swales and directed to the wet pond.

5.10.2 Basin 2 Drainage

Basin 2 is located on the west side of the study site, and generally drains from the east to the west towards a well-defined drainage channel that passes through the southwest corner of the study site. This drainage channel, which appears to be normally dry with the exception of some small pools, leads to Dog Pound Creek about 6 km to the northwest.

The proposed drainage system in Basin 2 is comprised mainly of the natural overland drainage, with several grass swales to direct runoff to the proposed wet pond located near the lowest point within Basin 2, near the southwest corner of the site. The location of the proposed wet pond and grass swales is shown in **Figure 5.1** . A swale is required along the west sides of the site, to prevent runoff from exiting the site uncontrolled, and instead direct runoff to the pond for storage, treatment and release at a controlled rate. Some re-grading near the proposed wet pond is required so that all runoff from Basin 2 is directed to the wet pond; the area potentially requiring some regarding is identified on **Figure 5.1.**

The wet pond has been shown as a rectangular pond on **Figure 5.1** ; however, the exact pond shape can be determined during detailed design, and could be incorporated into the golf course design. As shown in **Table 5.4**, the wet pond in Basin 2 must have an active storage volume of about 5,920 m^3 to accommodate runoff from the 1:100 year 24 hour rainfall event. Because the low spot in Basin 2 is occupied by several groundwater wells (based on the information provided in "Groundwater Evaluation – Chinook Ridge Lodge and Golf Course, SE-31-28-3-W.5" (Stantec Consulting Ltd., 2010), the pond will likely need to be located just north of the low area. Re-grading and some filling of this low spot to promote drainage to the wet pond is required based on the proposed wet pond location. If it is possible to relocate the groundwater wells, it may be possible to place the wet pond in the low spot, which will reduce the extent of the required re-grading.

The pond will discharge at a controlled rate of 0.21 m^3/s during severe rainfall events via an outlet structure and pipe to the drainage channel at the west boundary of the study site, that leads towards Dog Pound Creek. The pond and outlet structure will be designed so that the outlet pipe is contained on the study site. During more frequent and less severe rainfall events, it is expected that the wet pond will store most or all runoff (depending on the water level in the pond and the intensity of the rainfall event) to be used for golf course irrigation.

5.10.3 Offsite Contributing Area

As shown on **Figure 5.1** , an area of approximately 42.9 ha to the south of the study site drains via the natural topography to the study site. There is no road bordering the south side of the study site, so it is assumed that runoff from this area will naturally enter the site during significant rainfall events. Approximately 40 ha of this offsite contributing area drains to Basin 2 via the aforementioned drainage channel through the southwest corner of the study site, while the remaining area drains to Basin 1.

If this offsite runoff is allowed to flow onto the proposed golf course, it would need to be diverted to the wet ponds for treatment and release at a controlled rate. Therefore, it is recommended that the offsite runoff from south of the study site be diverted around the golf course using an earthen berm (or a drainage ditch), in order to eliminate the need for additional storage in each pond. This berm (or ditch) will prevent offsite runoff from flowing over the golf course and picking up any of the associated contaminants.

The offsite runoff will be diverted to the drainage channel in the southwest corner of the site. This drainage channel can be diverted along the edge of the study site via a swale, as shown on **Figure 5.1**, and released back into the natural drainage channel as it exits the study site. By diverting this drainage channel and the runoff from the offsite contributing area, that runoff can flow downstream without crossing the golf course.

In order to enhance the water quality in the diverted drainage channel and to incorporate LID features, it is recommended that trees and other natural features (such as small pools and wetland vegetation) be incorporated into the design of the diversion channel.

5.10.4 Stormwater Quality and Best Management Practices

The stormwater drainage system has not only been designed to control the peak flow rates and runoff volumes from the proposed development, but also to enhance the quality of stormwater released to adjacent land and watercourses. The most prevalent potential contaminants that are expected to originate on the proposed golf course and lodge include:

- Pesticides
- Fertilizers (source of excess nutrients)
- Hydrocarbons (typically originating in the parking lot, maintenance shop and possibly golf carts)
- Sediments (originating from sand applied in the winter, parking lot, etc.)
- Irrigation water (treated wastewater)

The following best management practices have been incorporated into the conceptual stormwater management design, and are aimed at preventing contaminant release to the environment and controlling the volume and peak flow of runoff:

<u>Source Control Best Management Practices</u>

- Divert runoff originating offsite around the golf course to reduce the runoff volume requiring treatment in the wet ponds and to reduce the migration of contaminants from the study site.
- Minimize impervious surfaces by using a permeable pavement and gravel walkways, in order to reduce stormwater runoff volumes and flow rates.
- Ensure that all chemicals or sources of potential contaminants (e.g. solvents, batteries, lubricants, fuel tanks) are stored properly.
- Avoid the use of road salt on the parking lot and walkways, and instead use sand/gravel for traction in winter.
- Ensure wastewater is conveyed, treated and stored properly, and is not subject to inundation by stormwater (see **Section 4.0** for wastewater treatment and storage).

Stormwater Conveyance Best Management Practices

- Use of the natural topography for most of the onsite drainage promotes sheet flow of runoff, which enhances infiltration and thus reduces the transport of contaminants and erosion.
- The proposed grass swales are used to prevent runoff from exiting the study site uncontrolled (which would cause contaminant migration offsite), and instead divert runoff to the wet ponds for treatment, reuse and controlled release. Grassed swales can also filter out some suspended solids and promote infiltration, especially if check dams are used at intervals along the swale to control the flow rate. Vegetation along the side of grass swales can enhance the water quality.

"End-of-Pipe" Best Management Practices

- The proposed wet ponds will promote the settling of solids, biodegradation of organics, uptake of nutrients by algae, in addition to controlling runoff volumes and flow rates to downstream land and watercourses. Use of vegetation around the perimeter of the wet pond can further enhance the effectiveness of contaminant removal.
- Stormwater reuse will reduce the volume of runoff and therefore the contaminant migration offsite.

5.10.5 Drainage Infrastructure Conceptual Design

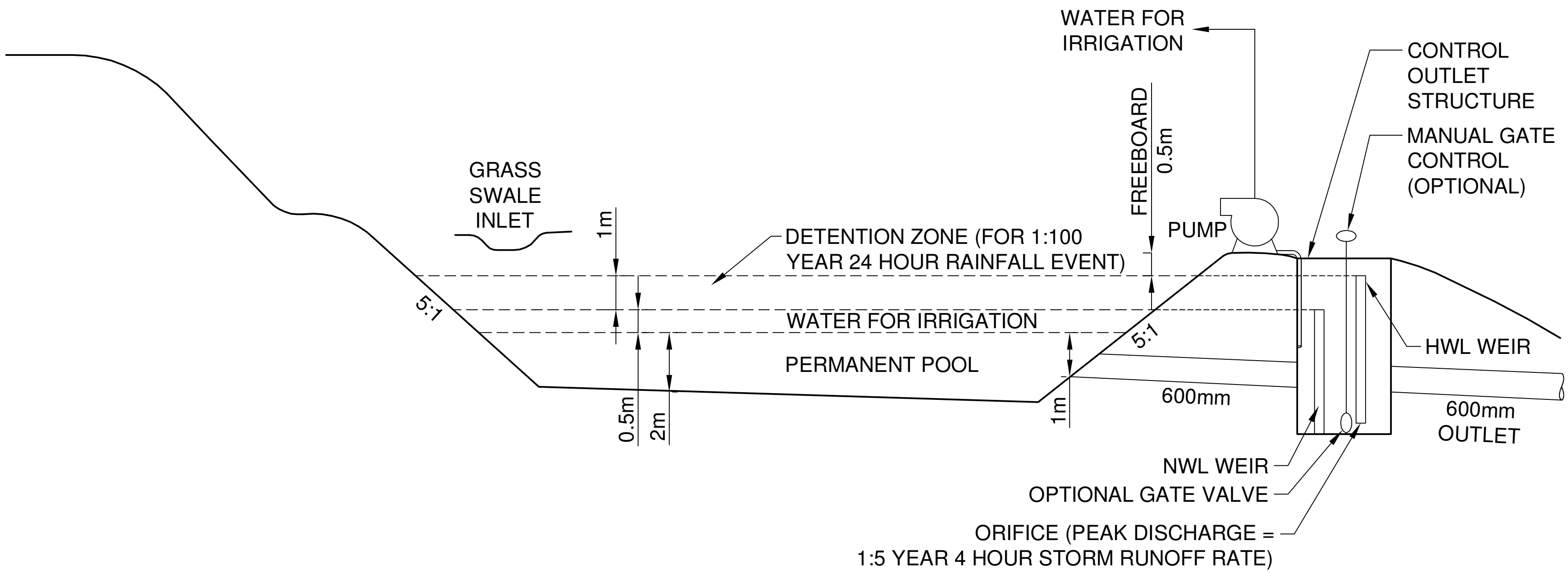
Figure 5.2 shows the conceptual design of the wet ponds and grass swales. Design considerations outlined in Alberta Environment's Stormwater Management Guidelines (1999) were used where appropriate. Site-specific considerations, such as the hilly terrain, have also been employed in the conceptual design.

Grass Swales

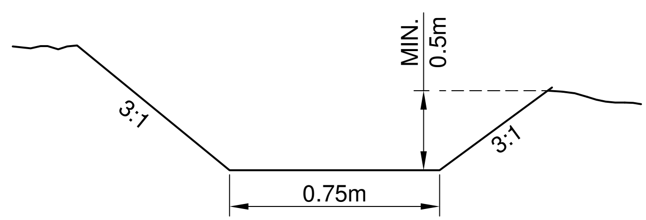
Grass swales should have a bottom width of 0.75 m and side slopes of 3:1, as indicated on **Figure 5.2**. The swales should be at least 0.5 m deep. Check dams could be placed at intervals in swales that are on steeper terrain to reduce the velocity in order to promote sediment settling and reduce erosion. Vegetation can also be planted along the edges of the swales for enhanced contaminant removal and aesthetics.

Berm

The proposed berm (for the diversion of offsite runoff around the golf course) can be constructed with the excavated material from the swales and/or wet ponds. The clayey soil found onsite should be appropriate for use in constructing the berm. The recommended berm sizing is 0.5 m high, with 3:1 side slopes and a top width of 1 m.



TYPICAL WET POND
N.T.S.



TYPICAL GRASS SWALE
N.T.S.

V:\1101\active\149104750_Chinook\drafting\figures\fig5_2.dwg
2011-08-15 12:22PM By: lgrebaz

August, 2011
1491-04750/400

Stantec

Client/Project
CHINOOK RIDGE LODGE AND GOLF COURSE LTD.
INTEGRATED WATER MANAGEMENT PLAN

Figure No.
5.2

Title
Typical Wet Pond and
Grass Swale Cross Sections

Wet Pond and Outlet Control Structure

The conceptual cross-section profile of the wet ponds is shown on **Figure 5.2**. The proposed wet ponds will be 4 m deep, including a 2 m deep permanent pool, a 0.5 m deep stormwater reuse zone, a 1 m deep active detention zone and 0.5 m of freeboard. The side slopes will be 5:1 for the entire pond. The active detention zone in each pond has capacity for approximately 6,200 m^3. The wet pond in Basin 1 should be placed at the lowest point, whereas the wet pond in Basin 2 is slightly above the lowest point so that it does not interfere with the groundwater wells. This conceptual pond design is based on a rectangular pond with sides 126 m by 63 m (at the top of freeboard), but the exact configuration can be varied so that it is incorporated into the golf course design. However, the 2 m permanent pool should be maintained to encourage adequate treatment of stormwater, and the active detention zone must have capacity for the volumes indicated in **Table 5.4**.

The pond will discharge via a pipe to an outlet control structure (**Figure 5.2**) containing a normal water level (NWL) weir with a crest 2.5 m above the pond bottom (2 m permanent pool plus 0.5 m for stormwater reuse). A high water level (HWL) weir with a crest height 3.5 m above the pond bottom is also located in the outlet control structure, but this weir is equipped with an orifice at the bottom that is sized to limit the release of water to the flow rates indicated in **Table 5.4**, which are equal to the peak runoff rate generated by the 1:5 year 4 hour rainfall event in pre-development conditions. Thus, on normal days, the pond water level will be maintained between 2 and 2.5 m, depending on water use for irrigation and inflow from storm runoff. Any runoff that causes the water level to increase to above 2.5 m will force water over the NWL weir and through the orifice in the HWL weir to the outlet. In the event of a severe rainfall event, the inflow to the pond may be higher than the discharge via the orifice, and water will build-up in the detention zone of the pond, and released at a controlled rate (via the orifice) during and after the rainfall event. If a rainfall event with return period in excess of 1:100 years occurs, the pond can overflow via the HWL weir.

Pipe flow calculations, assuming that the pond outlet pipes are concrete (Manning number = 0.013) and placed at a slope of 0.5%, indicate that 600 mm outlet pipes are required, and that the maximum velocity of discharge would be about 1.2 m/s. These pipes will daylight on the study site at a certain distance downstream of the outlet control structure. Appropriate erosion protection measures, such as the placement of rocks, should be incorporated at the discharge location.

5.10.6 Stormwater Reuse

It is recommended that stormwater collected in each wet pond be used for golf course irrigation as required. The reuse of stormwater will reduce the discharge of runoff to adjacent lands and watercourses, and eliminate the need for groundwater for irrigation. In these ways, stormwater reuse embodies the principles of LID, and is considered a best management practice in golf course operation. The storage and reuse of stormwater will permit the irrigation of the golf course during dry weather, and will be accomplished by installing pump stations at each wet pond.

It is assumed that the daily average irrigation water requirements for the greens and tee boxes for the proposed 18 hole golf course is approximately 80-100 m^3/day. Treated wastewater will also be used for irrigation, and the maximum daily volume of treated wastewater is 48.8 m^3/day when the lodge and cabins are occupied and the golf course and restaurant are at capacity. It is assumed that about 24 m^3/day of treated wastewater will be available on an average day. Therefore, the remaining 60-80 m^3/day of irrigation water can be supplied by stormwater facility. If the golf course operates for an average of 185 days per year, the required annual stormwater reuse for irrigation is 18,500 m^3.

In an average year, the study site receives approximately 450 mm of precipitation (based on the average annual rainfall at Calgary Airport and Olds; the study site lies approximately half way between these sites for which Environment Canada provides climate data). Assuming an annual runoff coefficient of 0.25, approximately 68,000 m^3 of runoff could be generated on the study site each year. Between the months of April and September, the runoff volume is estimated to be about 51,000 m^3. These numbers indicate that the available stormwater will be sufficient for the irrigation of the greens and tee boxes, and potentially the occasional irrigation of golf course fairways.

Another factor to consider in stormwater reuse is the available storage in the wet ponds. Based on the conceptual pond design, it is estimated that about 4,900 m^3 (total for both ponds) of storage is provided in the "water reuse" zone, between 2 and 2.5 m above the pond bottom. Thus, if the water level in the pond is maintained near 2.5 m deep during periods of intermittent wet weather, there is about 49 days worth of stormwater for the irrigation of greens and tees should a period of dry weather occur. The exact storage available for stormwater reuse will depend on the actual configuration of each wet pond. If the water level in the pond reaches 2 m depth, irrigation using stormwater should be stopped until a rainfall event replenishes the water supply. 2 m is the minimum permanent pool depth in a wet pond as recommended by Alberta Environment.

The orifice in the HWL weir (in the outlet control structure of each pond) could be equipped with a manually controlled gate valve (shown on **Figure 5.2**, and is optional). By closing the gate, the water level in the wet pond would be allowed to rise above the 2.5 m. Thus, additional water could be stored during periods of wet weather (e.g. in the spring) and used for irrigation during periods of dry weather. In the event of a severe rainfall event, the gates should be opened so that the water level does not surpass the HWL weir crest level and flow at an uncontrolled rate.

It is recommended that this gate valve be installed in the outlet control structure, but that it is normally kept in the open position. If additional stormwater is needed for irrigation, then the golf course operator may close the gate, but should understand that monitoring of the weather and pond water levels would be required while the gate is closed.