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PART D:

OPERATIONS AND LONG-TERM MONITORING

Part D: Operations and Long-Term Monitoring

This part of the report includes recommended operations, maintenance and monitoring activities for the Garden City Lands in accordance with the recommendations and preferred options for development of the site.

16. Agricultural Monitoring and Maintenance Activities

This is an adaptive management framework that includes best practices, monitoring, and maintenance recommendations for drainage and irrigation on the Garden City Lands. These steps will allow the City and the agricultural producer(s) to obtain the data necessary to determine if conditions are changing (positively or negatively), and whether particular actions need to be taken to repair any problems that may arise. Periodic evaluation of farm water use will also provide an opportunity to reassess water needs over time.

16.1 Drainage Ditches

Drainage Ditch Management Best Practices

- The freeboard in major ditches should be maintained at 1.2m, or the maximum possible based on the actual ditch inverts and the field surface elevations. Between storm events during the growing season the freeboard is especially important to allow drainage of the fields in production.
- When ditch cleaning operations are underway it is recommended that the ditch be dewatered and silt barriers be put in place to prevent sediment-laden water entering the City's storm sewers.
- Ensure protective plant cover is present along the stream/ditch banks to prevent erosion. There are several erosion control methods outlined the in the BC Ministry of Agriculture's Drainage Manual (1997).
- Mark all outfalls and surface water inlets for reference and for future maintenance.
- Confirm that all surface water inlets are fitted with a proper guard or grate to keep debris and trash out of the subsurface drainage system.
- Ensure that a grate or rodent guard is installed on all outfall pipes to prevent unwanted entry by burrowing animals.

Drainage Ditch Monitoring

- Inspect all surface water inlets twice per year (spring and fall), and ensure that all of the markers are still in place and clearly visible.
- Make thorough inspections of all outfalls in the spring, fall and after severe storm events when the soil is wet and the subsurface drains are running. Make sure that all of the markers are still in place and clearly visible.
- Remove any trash, debris or plant material that has accumulated around any inlets and end pipes to ensure that they continue to function properly.
- Look for any signs of reddish-orange gelatinous sludge coming from the outfall of a collector pipe into a ditch. This may indicate the presence of iron ochre, which may be coming from the aquitard and can plug the drainage system.

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- Look for signs of sediment in drain discharge and in the receiving ditch. Sediment at the drain outfall indicates that there is soil entering the pipe system from bad joints, crushed pipe or the need for a drain envelope. Quite a bit of sediment may come out of the system in its first year, but this should not persist.
- Under normal conditions, the outfall from a collector pipe into a ditch should flow free and clear from any sediment or debris.
- Monitor bank stability to ensure erosion is minimized and outflow areas for drain pipes are free and clear.

Drainage Ditch Maintenance

- Repair or replace grates or rodent guards if necessary to prevent unwanted entry by burrowing animals.
- Clean the receiving drain if it has accumulated sediment and is negatively affecting the outfall.
- Maintain (mow) vegetation in the drainage ditches to minimize impacts on water flow.
- Excavate the ditches every 10 years or more frequently if sediment accumulation in the bottom of the ditch exceeds 0.3 m.

16.2 Subsurface Drain Pipes

Drain Tile Best Practices

- The ideal times to inspect the system are in the spring, late fall and after a significant rainfall event – when the soil is wet and the drains are running.
- Drain tiles should be installed at a depth between 0.8m and 1.2m depth depending on peat depth and terrain. A minimum 1.0m depth will also help to offset land settling;
- The initial period following the installation of the new subsurface drainage system is critical to ensuring it functions properly over the long term. The soil around and above the drains will still be loose and should be left to settle naturally with time and rain.
- Avoid the use of heavy equipment to pack down the soil over the drains, as any heavy pressure on the loose soil could damage or collapse the pipes.
- Minimize traffic on the field for as long as practically possible after installation of the drain tile system, and straddle the laterals and mains with equipment or work across (not parallel to) the drains when working the field in the first year after installation.
- Keep records of any maintenance/repairs and changes to the system on the drainage plan. This will ensure that there is always an accurate plan of the system for future inspection and maintenance.

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Drain Tile Monitoring

- Some degree of settling or subsidence is expected to occur during the first few years as the peat and/or amended peat decomposes and subsides. Some effectiveness of the tile drains may be compromised as the land settles and therefore the drainage installation and maintenance programs should plan for this settling. The soil surface elevation during soil placement may exceed the design elevation to account for the soil settling.
- Check for any signs of erosion of the ground at drain pipe locations following rain events, especially in the first few years.
- Inspect the mains and laterals a couple of days after a heavy rainfall to look for any signs of ponding or excessive wet spots in the field. This may indicate that a blocked drain exists and will need to be repaired.
- Uniformity of crop growth is another good indicator of a properly functioning drainage system. Ideally, the field should dry evenly and produce similar yields.
- Take periodic aerial photographs of the farm to get an overview of the drainage system and to identify potential drainage problems. Drones with cameras are becoming affordable and would be an inexpensive way to obtain these photos.
- Check the settlement of backfill along the trench especially after the first winter. Deep holes may indicate a section of broken drainpipe requiring repair.
- Check for any signs of wash-ins and blow-outs, which can indicate that there is a broken drain pipe, and surface water has entered the drain. Repair the damage immediately to minimize the amount of sediment entering the subsurface drainage system reducing its hydraulic capacity. Flush out the pipes if necessary to remove built-up sediment downstream of the repair location. Observe vegetation growth along drain lines and weeds including undesired shrub and tree species that are close to the drainage lines before their roots enter and block the drain.
- Check for silt deposits at the pipe outlet, which can indicate a failure of filters, collapse of a drain, or an open joint.

Drain Tile Maintenance

- Silt boxes and catch basins may be installed at critical points in the system to capture sediment and allow for access for pipe cleaning. They should be inspected and cleaned out annually.
- Flushing the drain is also recommended. To flush and clean a drain, a reasonable supply of water must be available. High-pressure cleaning alone will not clean a significant distance down the drain; hoses may be required to flush the length of the drain tile
- Cleaning blocked subsurface drains involves digging holes down to the drain at intervals of 10–25 m, removing a short section of the drain, and inserting a steel rod with a hook or corkscrew end, or short-jointed sewer rods. The steel rod with the corkscrew end is inserted from the lower end of the drain until resistance is encountered. The rod is screwed into the sediment and removed several times.
- Persistent wet spots may indicate a plugged pipe. Dig up the drain at the wet spot and repair it or discard and replace it. If the fields are wet, it may be better to wait for drier conditions to make the repairs to avoid damaging the soil structure.

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16.3 Irrigation System

Irrigation Management Best Practices

- In the short term, potable water use is recommended until the water volume needed for irrigation is better defined. This has the combined benefit of providing confidence in water quality, as well as measurement of water use through metering.
- Sub-area metering could be a part of the irrigation system design such that specific fields and/or crops are metered to determine volumetric use over the course of the growing season. This will provide additional information if and when the possibility of switching to stored water or another water source becomes a feasible option. This data would also be useful if and when a sub-irrigation system is developed for the site.
- The development of agricultural fields will be phased and the irrigation volume is expected to increase as field acreage is put into production. Use of automated systems to apply the amount of water required for the crop during that time period is recommended, to reduce over and under watering. This may include setting up a controller, housed in a cabinet or other storage space that is connected to the irrigation system electronically.
- Use of trickle / drip irrigation systems are preferred as they are more efficient than other irrigation systems, however sprinklers may need to be used from time to time.
- A water budget should be calculated to determine when and how long to irrigate.
- It is important to determine the moisture content throughout the root zone to make an educated decision on when to start irrigating by using tensiometers or other equipment.
- A 'winterization' plan should be established to put the system to rest at the end of the irrigation season. This may include draining the system and reprogramming the automatic controller.
- A 'return to normal service' plan should be established to bring this system back into operation at the start of the irrigation season. This may include ensuring there is no damage to the system and reprogramming the automatic controller.
- Using potable water may require the irrigation system to be adjusted for water restrictions.

Irrigation System Monitoring

- Check irrigation equipment for leaks. Common faults include leaking gaskets, defective sprinkler bearings, and uneven pressure due to incorrect pipe sizes.
- Sprinklers: Check nozzles annually for wear. Worn, oversized nozzles will apply excess water to the crop. Check for missing, broken, or clogged heads. Check to see if the spray is covering the area uniformly and is targeting the appropriate area.
- Drip system: Check trickle/drip emitters annually for signs of clogging. Plugged emitters cause uneven water distribution. Ensure flush valves are operating, confirm operations water pressure.
- Controller (if applicable): Ensure the cabinet housing the controller is clean, and no wires are loose or worn. Check battery voltage and condition. Ensure the controller is programmed properly for the time of day, season, and any water conservation measures.

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- Inspect valves and valve boxes, ensure electrical connections are intact.
- Conduct a peak flow rate check for water withdrawal rate (see BC Ministry of Agriculture worksheets).
- Conduct an annual water use check for total water use (see BC Ministry of Agriculture worksheets).

Irrigation System Maintenance

- Sprinkler: replace missing or broken heads as needed, remove and clean clogged heads, adjust or replace tilted heads. Replace leaky valves and check for drainage problems. Trim vegetation or other obstructions around the sprinkler heads.
- Drip emitter: replace emitters that are no longer working efficiently. Replace tubing as needed. Change the filter periodically.
- Controller: Clean the cabinet out (remove cobwebs, dirt) and replace the battery seasonally. Reprogram to ensure the correct time and day is displayed. Tighten and replace wires as needed.

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17. Other Drainage Infrastructure Monitoring and Maintenance

17.1 Storm System Connections

Routine Operations and Maintenance

Primary storm system connections to drain runoff from the site will be located at or near the entrance to the Garden City Lands Site at the junction with Lansdowne Road on the West side of the site, and in the southwest corner of the bog preservation area, see Figure 2-1. These two connections are critical for maintaining drainage of excess water from the site and staff should check them routinely, on a daily basis as part of a general site check. The daily check need only be a visual observation of whether drainage is being impeded causing higher-than-normal water levels or flow form the storm sewer into the onsite ditches. If such observations are made during a routine check, they should be further investigated to determine the cause and addressing the issue if needed.

Additional storm system connections are located at various points around the periphery of the site as shown in Figure 2-1. These drain the perimeter trail areas and plazas at entry points. These storm system connections each drain less area and are not required to be checked as frequently. However, during times of heavy rainfall City staff should plan to check these drains to observe whether they are functioning normally.

Fen Wetland Outlet Management

The outlet structure for the fen wetland will have a variable level control requiring manual operation and adjustment. The outlet will be adjusted by manual insertion and removal of stop logs (boards) that incrementally raise and lower the spill elevation of the outlet between the minimum and the maximum elevations. The maximum ponding level for the fen wetland and therefore the maximum level for the stop logs is recommended to be 1.7 m Geodetic. The minimum level for the stop logs will be equal to the ground level (x.x m Geodetic).

Initially, the outlet elevation should be set to the ground elevation, the lowest spill level for the outlet. The spill elevation of the outlet should not be raised until the construction of all subsurface hydraulic barriers and aboveground berms are complete all the way around the bog conservation area.

Once construction of the hydraulic barriers and berms is complete, the spill elevation may be raised. The typical spill elevation for the outlet will be determined over time.

- When the spill level is first raised, it is recommended that the outlet be set at approximately 1.5 m elevation Geodetic, and not higher, until the site has experienced wet-season heavy rains and the City has had a chance to observe and monitor how the site behaves with that raised outlet elevation.
- If the site does not appear to be retaining water for a sufficient length of time into the spring, the spill elevation of the outlet should be raised to 1.7 m Geodetic the following year.
- If the site appears to be retaining water too well, and a lower level of ponding, or less area of inundation, is desired on the site, then the spill elevation of the outlet should be lowered the following year.

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- If at any time there appears to be leakage in the berms surrounding the bog conservation area and repairs are necessary, the ponding elevation on the fen wetland site can be temporarily lowered to allow repairs and/or drainage of the ponded volume of water to relieve the hydraulic pressure on the berms. Ideally, repairs would be done during the late summer when the site would naturally tend to be drier. If possible, draining of the ponded water should be delayed until late July/August to allow the bog to utilize retained water during the growing season for the bog vegetation. In addition, if the wetland water level needs to be lowered, it should only be lower as much as needed and not all the way to ground level by only removing the stop logs above the desired water level and leaving the lower ones in place.

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18. Groundwater Monitoring

The existing monitoring wells that were installed on the site in 2015 should remain in place to monitor the effects of changes to the site over time. It will take multiple years for the Garden City Lands site to be developed, and it is recommended that the monitoring wells should be maintained and the data recorded through the development of the site and after development.

The monitoring of the existing wells is expected to revert to the City at some point. Whether the monitoring is performed by City staff or by a contractor, the monitoring wells should be maintained in their current locations if possible through the development of the site and post-construction. There is no timeframe for which it is certain that monitoring is not needed, and monitoring of on-site groundwater levels is expected to be valuable for the long-term. It is recommended that at least a minimum of ten years of monitoring of groundwater should be planned after full farm build-out.

The current instrumentation has continuous recording of groundwater levels and the data is downloaded from each well manually at intervals. In order to be aware of the functioning of the instrumentation, it is recommended that each monitoring well should be checked and the data downloaded quarterly, if possible, and no less than semi-annually.

The collected data should be analyzed to determine if groundwater levels supporting the bog have improved over time subsequent to the surface and sub-surface hydraulic barriers being installed.

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19. Ecological Monitoring and Maintenance Activities

This report provides a number of recommendations and options for managing the natural areas to be conserved at Garden City Lands. It is not possible to provide detailed direction regarding management of the conservation area until there is a more confident understanding of the influence that the perimeter berms and hydrological barriers will have on the groundwater levels.

A primary goal of this strategy is to re-establish a plant community that best represents a bog ecosystem. Towards this end, it is recommended that mowing of the fen wetland/bog area cease and a vegetation monitoring program be undertaken for the first three years after hydrologic barriers are installed to better understand groundwater conditions and plant community composition outside of the influence of mowing and with the proposed groundwater containment. It is expected that after this monitoring period, more informed decisions can be made regarding whether or not it is possible to support a natural bog ecosystem on-site. Moreover, because of the large scale and associated costs of the potential treatments and maintenance, the options presented must be considered carefully by the City before committing to an approach and an outcome.

The following monitoring schedule supports recommendations based on implementation of the most comprehensive option for managing vegetation in the conservation area - Option 4 – Remove Invasive Species and Plant/Promote Bog Species and Sphagnum, with installation of wildlife habitat features.

19.1 YEAR 0 (2016)

Monitor Groundwater

- Continue monitoring program to better understand groundwater levels, water quality and chemistry.

Monitor Plant Species Composition - Vegetation Sample Plots

- Conduct surveys to identify and locate native bog-associated plants, including species such as Sphagnum, cloudberry, bog-rosemary, velvet-leaved blueberry, Labrador tea, bog laurel, bog blueberry, Chamisso’s cotton-grass. Occurrences of rare and sensitive plant species on site should be highlighted.
- Establish permanent sample plots within the remnant bog area for monitoring vegetation development and understanding vegetation response on a yearly basis:
    - Plots should consist of 20 m x 20 m areas identified by permanent stakes, established every 100 m in a grid pattern, targeting approximately 28 plots in total.
    - Micro plots measuring 1 m x 1 m should also be established within each monitoring plot.
    - Initial assessment of each plot should occur in late spring, and should include an inventory of key vegetation species and a visual estimate of species ground cover. Ideally, a baseline sampling should be completed prior to construction of any berms.
    - Point monitoring should be established via photo stations at each plot corner with photos taken at a height marked on the stake and facing each cardinal direction.
    - As visual estimates can be subjective, it would be ideal if the same individual assess the plots every year.

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Invasive Species Management

- Invasive species should be aggressively removed by hand, particularly those in proximity to rare or sensitive native bog-associated plant species.

Vegetation/Habitat Management

- Competitive vegetation should be cleared from around existing critical bog species including the remaining pockets of sphagnum. After 3 growing seasons, it is expected that there will be a better understanding of the groundwater hydrology after the installation of the hydrological barriers and the plant community composition that can establish under the new site conditions. This will allow for the development of a more refined strategy for long term management of the plant communities.
- Plant vegetation within the Recreation Interface Area as listed in Section 4.3 and maintain according to BCSLA guidelines.
- Install habitat features as described in Section 5.

19.2 YEARS 1-2 (2017-2018)

Monitor Groundwater

- Ongoing monitoring of groundwater levels, water quality and chemistry.

Monitor Plant Species Composition - Vegetation Sample Plots

- Each plot area should be inventoried every year in late spring, with key vegetation species and a visual estimate of species ground cover completed, per steps recommended above.
- Partnerships with stewardship groups already active in the area should be promoted in cooperation with City staff. Tasks may include initial monitoring of plant communities, and identification and maintenance of specific bog species.

Invasive Species Management

- Invasive species should be aggressively removed in these years.

Vegetation/Habitat Management

- Healthy bog species, including the remaining sphagnum pockets, should be protected and competitive vegetation removed.
- Replace any plants that failed to establish within the Recreation Interface Area and maintain per BCSLA guidelines.
- Continue to install, or replace or re-establish habitat features as described in Section 5.

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19.3 YEAR 3 (2019)

Monitor Groundwater

- Analyze findings from monitoring of groundwater levels, water quality and chemistry.

Monitor Plant Species Composition - Vegetation Sample Plots

- Continue to inventory sample plots every year. Analyze findings from first three years and recommend an approach to managing the conservation area with key vegetation species and a visual estimate of species ground cover completed, per steps recommended above.
- Work with stewardship groups where feasible, including monitoring of plant communities, and identification and maintenance of specific bog species.

Invasive Species Management

- Continue annual maintenance of invasive plant species.

Vegetation/Habitat Management

- Actively protect significant bog species and remove competitive vegetation.
- Assuming that the perimeter berms and hydrological barriers are installed within the first two years, vegetation should be restored within each of the conservation areas, as determined by the results of the monitoring program.
- With a better understanding of the plant community dynamics based on the hydrological regime, plant bog, lagg and/or wetland vegetation within respective areas.
- A variety of bog plant species should be transplanted within some of the permanent sample plots and monitored for survival and growth. Recommended species include indicators of healthy bog ecosystems, such as sphagnum, bog cranberry, cloudberry, Labrador tea and western bog laurel.

19.4 YEARS 4-10 (2019 – 2025)

Monitor Groundwater

- Depending on the confidence of findings from the first three years, potentially continue the groundwater monitoring program.

Monitor Plant Species Composition - Vegetation Sample Plots

- Depending on the confidence of findings from the first three years, potentially continue to inventory sample plots in Years 4 and 5.
- Continue to work with stewardship groups where feasible, including monitoring of plant communities, and identification and maintenance of specific bog species.

Invasive Species Management

- Continue annual maintenance of invasive plant species.

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Vegetation/Habitat Management

- Actively protect significant bog species and remove competitive vegetation for Years 4 through 6 at least.
- Re-plant any plant species that failed to establish, per BCSLA guidelines. Plants should be maintained carefully for at least 3 years after planting.

Figure 19-1 provides a schedule of recommended treatments over the next 10 years, and can be updated once there is a greater understanding of the groundwater function and plant community dynamics.

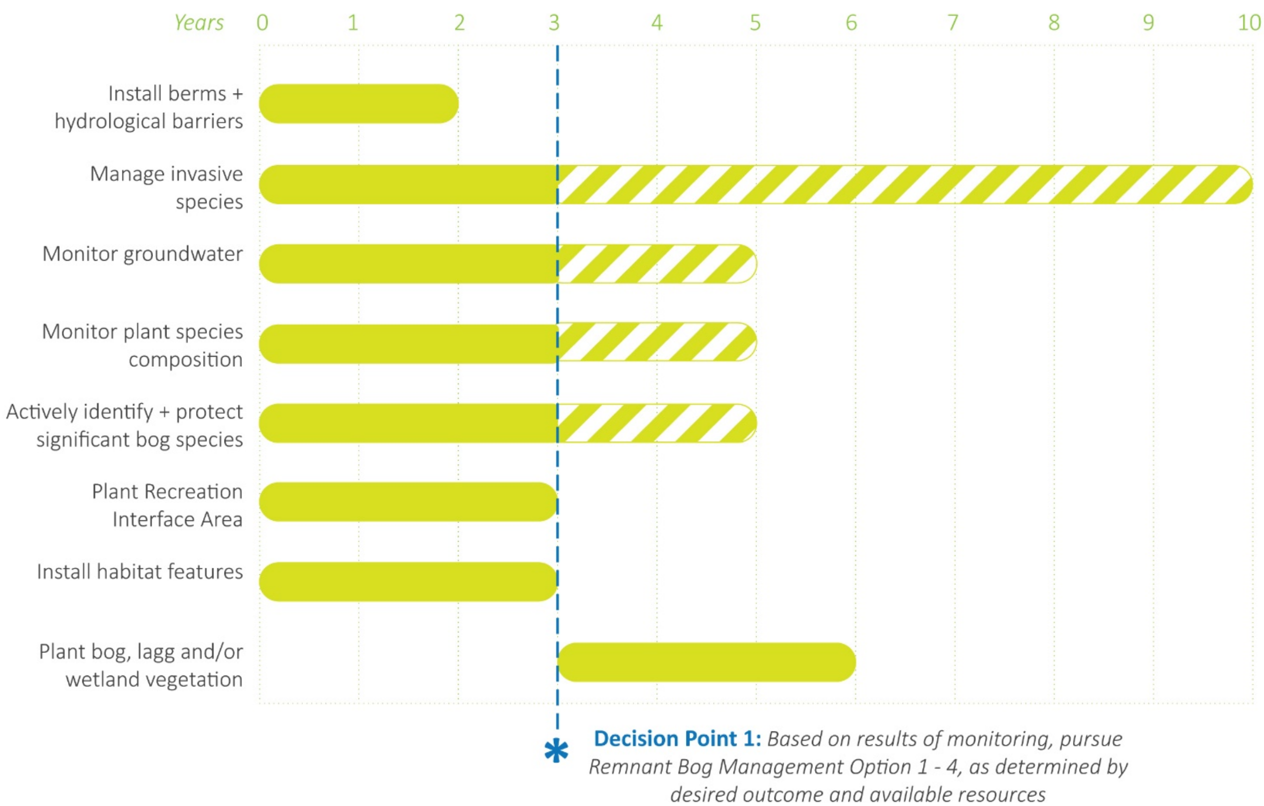

Figure 19-1: Treatment Schedule

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21. Report Submission

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1	December 2016	Final	Revised in accordance with comments from City Staff	LM/All
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