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Memorandum

To: Zahra Parhizgari, Environmental Engineer (City of Markham)

Rober Muir, Manager, Stormwater (City of Markham)

From: Tammy Karst-Riddoch, Principal (BlueCycle Canada, Inc.)

Date: April 23, 2026

Re: Swan Lake Submerged Aquatic Plant Survey

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1. Introduction

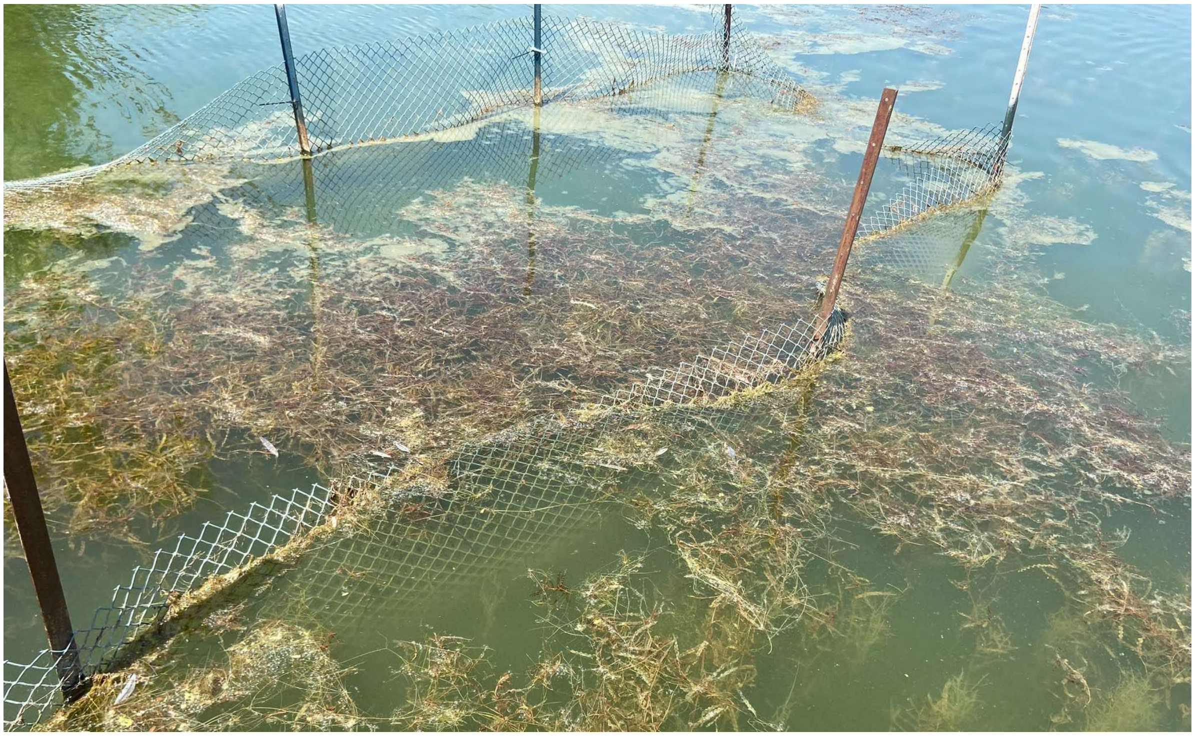
Historically, submerged aquatic vegetation (SAV) was rare or absent in Swan Lake primarily due to poor water clarity associated with elevated phytoplankton biomass. Although internal and external nutrient controls implemented under the Swan Lake Long-Term Management Plan (Markham 2021) significantly reduced phytoplankton, in 2023, the lake remained phytoplankton dominated with only modest improvements in water clarity. The persistence of phytoplankton dominance may, in part, reflect the absence of SAV, which under low-light conditions is competitively displaced by phytoplankton, reinforcing a turbid-state for the lake.

A pilot SAV planting program was initiated by the City of Markham in June 2023 and continued in 2024 to promote SAV establishment and improve water clarity through enhanced nutrient uptake, sediment stabilization, and competition with phytoplankton. A total of 3000 Wild Celery (*Vallisneria americana*) stems were planted in fenced enclosures along the north shore of the lake. While establishment of Wild Celery was generally low at about 30% within the enclosures, abundant natural colonization by other species of SAV was observed throughout the lake in June 2024 (Figures 1 and 2). During the lake treatment with polyaluminum chloride (PAC) for internal phosphorus control, densities of SAV, in particular Small Pondweed (*Potamogeton pusillus*), were sufficient to impede boat movement in some areas during the lake. This was the first documented occurrence of significant SAV in Swan Lake.

In 2025, the City completed an aquatic plant survey to characterize the newly established SAV community within defined lake management zones and depth strata of Swan Lake. This memorandum presents the results of the survey and their implications for ongoing lake management decisions.

Figure 1. Submerged aquatic plants visible in Swan Lake, June 18, 2024

Figure 2. Submerged aquatic plants within an enclosure for the pilot Wild Celery planting project, June 18, 2024



2. Methods Summary

The survey followed the methodology outlined in the Swan Lake Aquatic Plant Survey Plan (AECOM 2025) and integrates:

- A semi-quantitative Point-Intercept Survey to define species distribution and percent cover; and
- A quantitative Stratified Random Rake-Toss Biomass Survey to estimate wet biomass.

The field surveys were conducted between July 10-12, 2026, to coincide with peak macrophyte biomass conditions.

Point-Intercept Surveys were conducted at 45 pre-established grid locations distributed throughout the lake and representing a range of lake depths and management zones. At each location:

- Water depth and Secchi depth were recorded.
- Percent aquatic plant cover was visually estimated within an approximately 1-m^2 area using categorical cover classes (Absent, Trace, Low, Moderate, High) where possible.
- Two rake tosses were completed to identify species present and relative cover using the categorical cover classes.
- Species were identified in the field or preserved for confirmation.
- Observations of surface algae were recorded where present.

At 25 of the survey sites:

- Dissolved oxygen concentration was measured at 0.5 m below the water surface
- Plants retrieved from rake tosses were collected and sorted by species.
- Surface water was removed using a standardized spinning method.
- Wet weight was measured to ±0.1 g for each sample by species per rake toss.

The survey data were used to delineate plant bed types, characterize aerial coverage, biomass and species composition across the lake within lake management zones and lake depth areas.

Aquatic plant survey data are included in **Appendix A**.

3. Results

Aquatic vegetation was widely distributed throughout Swan Lake at the time of the 2025 survey, with submerged aquatic vegetation (SAV) observed at most sampled locations. Secchi depth ranged from approximately 0.3 to 0.95 m, indicating moderate to good water clarity relative to historical conditions. Surface water temperatures were elevated, ranging from approximately 25 to 28°C, consistent with peak summer conditions. Surface dissolved oxygen concentrations were generally high (approximately 8 to 16 mg/L) and frequently exceeded 100% saturation (up to approximately 200% at some sites), indicating localized supersaturation associated with high rates of photosynthetic activity. These conditions are consistent with abundant macrophyte and/or algal biomass and reflect strong daytime oxygen production within the lake. Elevated dissolved oxygen and supersaturation under daytime conditions are indicative of high biological productivity and do not represent water quality impairment.

The SAV community was dominated by native species, including Muskgrass (*Chara spp*.), Canada Waterweed (*Elodea canadensis*), Small Pondweed (*Potamogeton pusillus*), and Coontail (*Ceratophyllum demersum*). Muskgrass was the most prevalent species, occurring at approximately 90–95% of sites and typically at high cover. Canada Waterweed was also widely distributed (55–65% of sites) and frequently co-occurred with Muskgrass at moderate to high cover. Coontail and Small Pondweed occurred less frequently (40–50% and 30–40% of sites, respectively). Coontail was generally present at low abundance, whereas Small Pondweed exhibited a patchy distribution with occasional areas of high cover (Table 1).

Table 1. Species Occurrence and Cover

Species	Occurrence (%)	Typical Cover	Notes
Muskgrass (*Chara spp.*)	~90–95%	High	Dominant, widespread
Canada Waterweed (*Elodea canadensis*)	~55–65%	Moderate–High	Frequently co-occurs with Muskgrass
Coontail (*Ceratophyllum demersum*)	~40–50%	Trace–Low	Widespread but low abundance
Small Pondweed (*Potamogeton pusillus*)	~30–40%	Patchy (locally high)	Localized dominance

Notes: Based on point-intercept survey data; occurrence represents percentage of sites where species were observed.

Aquatic plant cover was predominantly high, with approximately 84% of sites classified as high cover. Areas of low or trace cover were limited and primarily associated with deeper locations. Complete absence of vegetation was observed at only a small number of sites, generally at depths exceeding approximately 2.5 m. The spatial distribution of plant cover (Figure 3) illustrates the widespread establishment of SAV.

SAV was consistently present in shallow (<1 m) and intermediate (1–2 m) depth ranges, where both cover and biomass were highest. Vegetation extended into deeper areas of the lake, with occurrences recorded at depths of approximately 2.4–2.7 m; however, both cover and biomass declined with increasing depth, consistent with light limitation (Table 2).

SAV was observed across all management zones, with no clear spatial limitation. Both high cover and elevated biomass were observed in multiple zones, indicating lake-wide establishment. The distribution of sampled sites by depth and management zone (Table 3) demonstrates representative coverage. Overall, vegetation patterns are more strongly related to depth than to management zone.

Figure 3. Spatial distribution of submerged aquatic vegetation (SAV) cover in Swan Lake based on point-intercept survey results, with bathymetric contours (m asl).

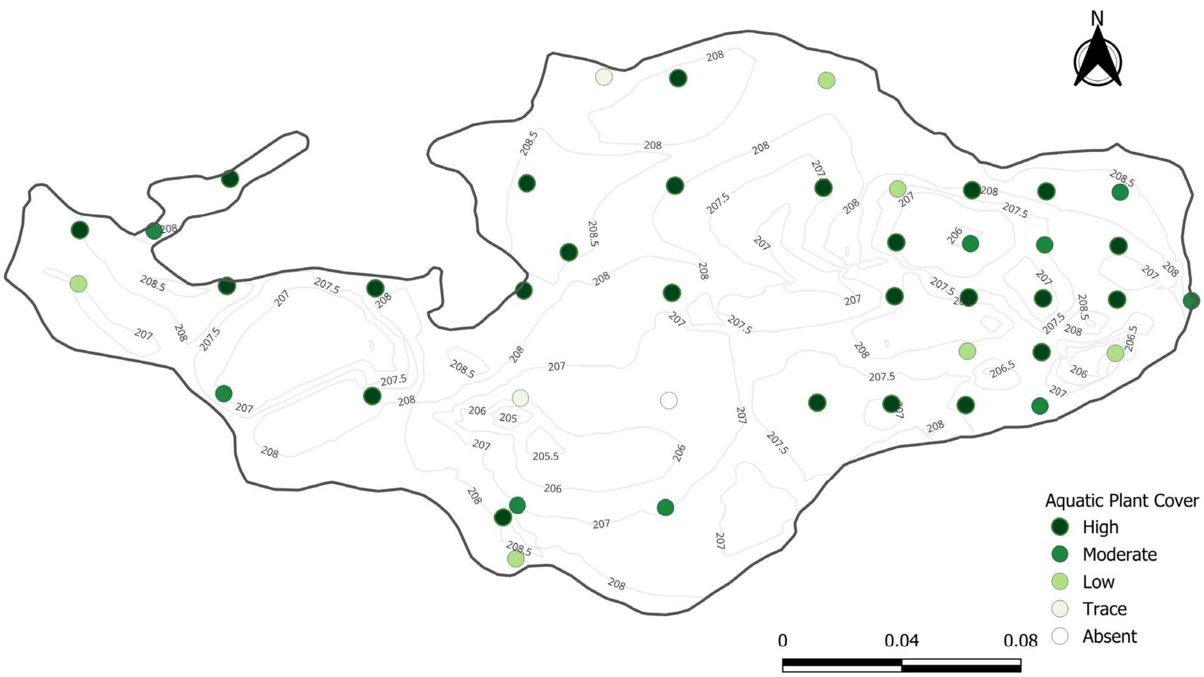


Table 2. SAV Distribution by Depth

Depth Range	Cover	Biomass	Interpretation
<1 m	High	High	Optimal growth
1–2 m	Moderate–High	Moderate	Active zone
>2 m	Variable	Low	Light-limited

Table 3. Sample Distribution by Zone and Depth

Zone	<1 m	1–2 m	>2 m	Total
1	5	5	5	15
2	4		4	8
3	7	1	6	14
4	2			2
5	3		3	6
Total	**21**	**6**	**18**	**45**

Quantitative biomass measurements indicate that SAV is both widespread and ecologically significant. Biomass ranged from trace amounts (<0.5 g) to greater than 650 g per sample, with most values between approximately 20 and 200 g. Muskgrass was the dominant contributor to total biomass, frequently exceeding 100 g and reaching a maximum of approximately 650 g. Canada Waterweed contributed moderate biomass, while Small Pondweed was locally abundant and Coontail contributed minimally. Biomass was highest in shallow to intermediate depths, particularly where Muskgrass dominated. These densities indicate well-developed plant beds capable of influencing sediment stability, nutrient cycling, and overall water quality (Table 4).

Table 4. Biomass Summary by Species

Species	Min (g)	Max (g)	Range (g)	Relative Contribution
Muskgrass	<1	~650	50–300	Dominant
Canada Waterweed	<1	~125	10–100	Moderate
Small Pondweed	<1	~25	5–30	Localized
Coontail	<1	~20	<10	Low

4. Discussion

The 2025 survey confirms that Swan Lake now supports a well-established and ecologically significant SAV community. Vegetation occurs across all management zones and extends through shallow and intermediate depths, with colonization to approximately 2.5 m. This distribution, together with moderate to high cover and substantial biomass, indicates that SAV is no longer strongly light-limited across much of the lake and reflects a marked improvement in condition.

The community is dominated by native species, particularly Muskgrass and Canada Waterweed, characteristic of stable, clear-water systems. Muskgrass plays an important role in sediment stabilization and limiting nutrient resuspension. The presence of multiple native species indicates that conditions now support sustained macrophyte growth and community development.

SAV establishment is consistent with improved water quality resulting from nutrient management. Reductions in phosphorus and associated declines in phytoplankton biomass have increased light availability, enabling macrophyte colonization. Once established, SAV reinforces these improvements through sediment stabilization, nutrient uptake, and competition with phytoplankton. The consistent distribution across all management zones indicates a lake-wide response.

Although limited establishment of Wild Celery was previously attributed to insufficient water clarity, the 2025 results indicate that light is no longer a primary constraint. The absence of Wild Celery, despite successful colonization by other species, suggests that species-specific factors, competitive interactions, and localized conditions within enclosures were more likely responsible.

Depth remains the primary control on SAV distribution, with highest cover and biomass in shallow and intermediate areas and reduced presence beyond approximately 2–2.5 m, consistent with light limitation. No clear relationship with management zones was observed.

Elevated dissolved oxygen and frequent supersaturation reflect high rates of daytime photosynthesis. Aquatic systems with abundant SAV also exhibit diel variability, including nighttime reductions in dissolved oxygen due to respiration and increased oxygen demand during periods of senescence. These dynamics are typical of shallow, warm-water lakes with well-developed SAV communities and reflect natural ecosystem function rather than impairment. In contrast to historical conditions, such fluctuations are not expected to result in widespread or persistent low-oxygen conditions.

Collectively, these findings indicate that Swan Lake has transitioned to a stable, macrophyte-influenced condition with improved water quality and ecological function.

5. Management Implications

The 2025 survey indicates that SAV is well established and self-sustaining within Swan Lake. Additional planting is not required, as the existing community provides key ecological functions, including sediment stabilization, nutrient uptake, and habitat support.

Future management should focus on maintaining conditions that support SAV persistence, including continued control of nutrient inputs and protection of existing vegetation from disturbance. Periodic monitoring (every 3–5 years) is recommended to assess long-term stability and detect changes in community structure.

While the community is dominated by submerged species, limited diversification (e.g., floating-leaved species) could be considered to enhance habitat complexity; however, such measures are not necessary to achieve current objectives.

Dense SAV has implications for in-lake treatments. To ensure effective deposition of products such as PAC, applications should occur during periods of minimal biomass (early spring prior to establishment or late summer–fall following senescence). Treatment during peak growth may result in interception by vegetation and reduced effectiveness.

6. Conclusions

The 2025 aquatic plant survey confirms that Swan Lake now supports a widespread and well-established submerged aquatic vegetation (SAV) community dominated by native species. Vegetation is distributed across all management zones and extends through shallow and intermediate depths, with colonization occurring to approximately 2.5 m. These findings indicate that light availability and overall water quality conditions are sufficient to support sustained macrophyte growth across much of the lake.

The observed SAV community reflects a fundamental shift from a phytoplankton-dominated system to a macrophyte-influenced condition, consistent with improvements in water quality following nutrient management. The absence of Wild Celery (Vallisneria americana) and the widespread natural colonization by other native species indicate that recovery is being driven by improved environmental conditions rather than active planting.

Given the extent and density of SAV, the current vegetation community is expected to provide key ecological functions, including sediment stabilization, nutrient uptake, and support for aquatic habitat. As such, additional planting is not warranted, and future management should focus on maintaining conditions that support SAV persistence through continued nutrient control and periodic monitoring.

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Tammy Karst-Riddoch, PhD
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BlueCycle Canada, Inc.

Appendix

Table A1 – Site Properties

Site ID	Depth (m)	Secchi Depth (m)	DO (mg/L)	DO Sat (%)	Temperature (C)	Cover	Latitude	Longitude	Zone	Actual Depth Category
ENC_001	0.6	0.5	9.62	120.3	27	H	43.89722	-79.2531	2	<1 m
ENC_002	0.4	0.4				H	43.89722	-79.2531	2	<1 m
ENC_003	0.95	0.8				H	43.89611	-79.2533	1	<1 m
SL_002	2	0.65	10.1	127.8	27.7	L	43.89709	-79.2551	2	1–2 m
SL_003	1.2	0.65				H	43.89732	-79.2551	2	1–2 m
SL_006	0.5	0.5	10	122	22.5	M	43.89731	-79.2548	4	<1 m
SL_007	2	0.7				M	43.89663	-79.2545	2	1–2 m
SL_009	0.7	0.7	10.8	128	27.9	H	43.89708	-79.2545	2	<1 m
SL_010	0.5	0.5	16	199	27.8	H	43.89753	-79.2545	4	<1 m
SL_016	1.75	0.6	10	126	27.2	H	43.89662	-79.2539	2	1–2 m
SL_018	0.8	0.5				H	43.89707	-79.2539	2	<1 m
SL_023	0.35	0.35				L	43.89594	-79.2533	3	<1 m
SL_024	1.1	0.9				M	43.89616	-79.2533	3	1–2 m
SL_026	2.4	0.95				T	43.89661	-79.2533	1	>2 m
SL_028	0.3	0.3				H	43.89706	-79.2532	1	<1 m
SL_030	0.48	0.48				H	43.89751	-79.2532	5	<1 m
SL_041	2	0.8				T	43.89796	-79.2529	5	1–2 m
SL_043	0.55	0.55				M	43.89615	-79.2527	3	<1 m
SL_045	2.7	0.9				A	43.8966	-79.2526	1	>2 m
SL_047	0.5	0.5	9.11	112.5	26.2	H	43.89705	-79.2526	1	<1 m
SL_049	0.66	0.66				H	43.8975	-79.2526	5	<1 m
SL_051	1.2	0.8				H	43.89795	-79.2526	5	1–2 m
SL_063	1.1	0.95				H	43.89659	-79.252	1	1–2 m
SL_067	1.5	0.7	8.45	104	25.5	H	43.89749	-79.252	5	1–2 m
SL_069	0.5	0.5	7.9	96.9	25.7	L	43.89794	-79.252	5	<1 m
SL_070	1.8	0.67				H	43.89659	-79.2517	3	1–2 m
SL_072	0.8	0.8				H	43.89704	-79.2517	1	<1 m
SL_073	2.4	0.6				H	43.89726	-79.2517	1	>2 m
SL_074	1.1	0.7				L	43.89749	-79.2517	1	1–2 m
SL_076	1.2	0.77				H	43.89658	-79.2514	3	1–2 m
SL_077	1.2	0.65	8.85	110.9	27	L	43.89681	-79.2514	1	1–2 m
SL_078	1.2	0.7				H	43.89703	-79.2514	1	1–2 m
SL_079	2.2	0.7	9.48	118.5	27	M	43.89726	-79.2514	1	>2 m
SL_080	0.65	0.65	9.4	119	27.4	H	43.89748	-79.2514	3	<1 m

Site ID	Depth (m)	Secchi Depth (m)	DO (mg/L)	DO Sat (%)	Temperature (C)	Cover	Latitude	Longitude	Zone	Actual Depth Category
SL_081	0.65	0.65	8.3	101.8	25.6	M	43.89658	-79.2511	3	<1 m
SL_082	1.5	0.75				H	43.8968	-79.2511	3	1–2 m
SL_083	2.3	0.8				H	43.89703	-79.2511	1	>2 m
SL_084	1.4	0.7				M	43.89725	-79.2511	1	1–2 m
SL_085	1	0.7				H	43.89748	-79.2511	3	1–2 m
SL_086	0.61	0.61	8.11	100.2	25.8	L	43.8968	-79.2508	3	<1 m
SL_087	0.95	0.9				H	43.89702	-79.2508	3	<1 m
SL_088	1.4	0.7				H	43.89725	-79.2508	3	1–2 m
SL_089	N/A	0.6				M	43.89747	-79.2507	3	>2 m
SL_090	0.9	0.72	8.21	102	26.1	M	43.89702	-79.2504	3	<1 m

Table A2 – Point-Intercept Data

Site ID	Sample #	Species	Proportion Code
ENC_001	1	MG	H
ENC_001	1	CW	H
ENC_001	1	CP	T
ENC_002	1	MG	L
ENC_002	1	CW	M
ENC_002	2	MG	H
ENC_002	2	CP	T
ENC_002	2	CW	T
ENC_003	1	CW	H
ENC_003	1	MG	L
ENC_003	1	CP	T
ENC_003	1	PP	T
ENC_003	2	MG	H
ENC_003	2	CP	T
SL_002	1	PP	H
SL_002	2	PP	H
SL_003	1	MG	H
SL_003	2	MG	M
SL_003	2	CW	M
SL_006	1	CW	M
SL_006	1	MG	M
SL_006	2	MG	M
SL_006	2	PP	M
SL_006	2	CW	T
SL_007	1	CW	M

Site ID	Sample #	Species	Proportion Code
SL_007	1	PP	M
SL_007	2	PP	H
SL_009	1	MG	H
SL_009	2	MG	H
SL_010	1	CP	T
SL_010	1	MG	M
SL_010	1	CW	M
SL_010	2	MG	H
SL_010	2	CP	T
SL_016	1	CW	H
SL_016	1	MG	H
SL_016	2	MG	H
SL_018	1	MG	H
SL_018	1	CP	T
SL_018	2	MG	H
SL_018	2	CP	T
SL_023	1	MG	H
SL_023	2	MG	H
SL_023	2	CW	T
SL_024	1	MG	H
SL_024	2	MG	H
SL_024	2	CP	T
SL_026	1	PP	H
SL_026	2	PP	H
SL_028	1	MG	H
SL_028	2	MG	H
SL_030	1	CW	H
SL_030	1	MG	T
SL_030	2	MG	H
SL_030	2	PP	T
SL_041	1	-	A
SL_041	2	CW	H
SL_043	1	MG	H
SL_043	2	MG	H
SL_045	1	-	A
SL_045	2	-	A
SL_047	1	MG	H
SL_047	1	CP	T
SL_047	2	MG	H
SL_049	1	MG	H
SL_049	1	CP	T

Site ID	Sample #	Species	Proportion Code
SL_049	2	MG	H
SL_049	2	CP	T
SL_051	1	MG	H
SL_051	2	MG	H
SL_051	2	CW	L
SL_063	1	MG	H
SL_063	2	MG	H
SL_067	1	CP	M
SL_067	1	PP	M
SL_067	1	CW	T
SL_067	2	MG	H
SL_069	1	CW	H
SL_069	2	MG	H
SL_069	2	CP	T
SL_070	1	PP	H
SL_070	1	CP	T
SL_070	1	CW	T
SL_070	2	PP	H
SL_070	2	CP	T
SL_071	1	MG	H
SL_071	2	-	A
SL_072	1	MG	H
SL_072	2	MG	H
SL_073	1	MG	H
SL_073	1	CP	L
SL_073	1	PP	T
SL_073	2	-	A
SL_074	1	MG	H
SL_074	2	CW	H
SL_076	1	MG	H
SL_076	2	MG	H
SL_076	2	CP	T
SL_077	1	MG	H
SL_077	2	MG	H
SL_078	1	MG	H
SL_078	2	MG	H
SL_078	2	CP	L
SL_079	1	-	A
SL_079	2	-	A
SL_080	1	MG	H
SL_080	2	PP	H

Site ID	Sample #	Species	Proportion Code
SL_081	1	MG	H
SL_081	1	CW	T
SL_081	2	CW	H
SL_082	1	MG	H
SL_082	2	MG	H
SL_083	1	-	A
SL_083	2	MG	L
SL_083	2	CW	H
SL_084	1	CP	M
SL_084	1	PP	M
SL_084	2	CW	H
SL_084	2	CP	L
SL_085	1	MG	H
SL_085	2	MG	H
SL_085	2	CP	T
SL_086	1	CW	H
SL_086	1	CP	T
SL_086	2	MG	H
SL_087	1	MG	H
SL_087	1	CW	T
SL_087	1	CP	T
SL_087	2	MG	H
SL_087	2	CW	L
SL_087	2	CP	T
SL_088	1	PP	T
SL_088	2	MG	H
SL_088	2	CW	L
SL_088	2	CP	T
SL_089	1	MG	H
SL_089	1	CP	T
SL_089	2	MG	H
SL_089	2	CW	L
SL_089	2	CP	T
SL_090	1	MG	H
SL_090	2	MG	H

Table A3 – Biomass Data

Site ID	Sample #	Species	Weight (grams)
ENC_001	1	MG	10.5
ENC_001	1	CW	9
ENC_001	1	CP	<0.5
ENC_001	2	MG	192.5
ENC_001	2	CW	12
ENC_001	2	CP	2.5
SL_002	1	PP	16.5
SL_002	2	PP	23.5
SL_003	1	MG	176
SL_003	2	PP	21.5
SL_003	2	CW	58
SL_009	1	MG	341
SL_009	2	MG	128
SL_009	2	CP	<1
SL_016	1	CW	124
SL_016	1	MG	224
SL_016	1	CP	<1
SL_016	2	CW	9.5
SL_016	2	CP	3
SL_016	2	MG	653
SL_047	1	MG	100
SL_047	1	PP	<0.5
SL_047	1	CP	<0.5
SL_047	2	MG	48.5
SL_067	1	CP	20
SL_067	1	PP	26
SL_067	1	CW	2
SL_067	2	MG	78
SL_067	2	CP	<1
SL_069	1	MG	28
SL_069	2	MG	46.5
SL_077	1	MG	23
SL_077	1	CW	10.5
SL_077	2	MG	32.5
SL_080	1	PP	2.5
SL_080	1	MG	17
SL_080	1	CW	<0.5
SL_080	2	MG	64
SL_080	2	CW	<0.5

SL_081	1	MG	194.5
SL_081	1	CW	<0.5
SL_081	2	CW	123.5
SL_081	2	MG	31
SL_086	1	CW	22
SL_086	1	CP	1
SL_086	2	MG	130
SL_090	1	MG	167
SL_090	1	CW	16
SL_090	2	MG	23.5