Appendix 7.2

Species-at-Risk Field Investigation

To: Cameron Gorrie
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From: Lisa Uskov
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File: Talbotville WWTF

Date: December 8, 2015

Reference: Talbotville Waste Water Treatment Facility Constraints Review for EIS

INTRODUCTION

The Township of Southwold retained Stantec Consulting Ltd. (Stantec) to undertake an investigation of Natural Heritage Features as part of a Municipal Class Environmental Assessment (Class EA) for the proposed wastewater treatment facility (the Facility) located in Talbotville, Ontario.

There are two locations proposed for the development of the Facility: one located on a parcel on the east side of Sunset Road (the North Site) (Attachment 1); and one located on the south side of Talbotville Gore Road (the South Site) (Attachment 2).

APPLICABLE LEGISLATION

The following sections describe legislation referenced throughout the memo as it pertains to the Natural Heritage Features on the proposed sites. It does not consider legislation related to any other discipline or practice, and should not be considered complete or accurate for legal purposes.

TOWNSHIP OF SOUTHWOLD OFFICIAL PLAN, 2014

S. 2.6 of the Township of Southwold Official Plan (OP) requires groundwater impact assessments and assurance that water quality and quantity will not be negatively impacted by development as appropriate to the level of susceptibility.

S. 2.1 of the OP defines Hazard Lands as lands that are susceptible to flooding and/or instability due to erosion and steep slopes. Development is restricted in these areas for environmental, safety, and economic reasons. S. 2.3 of the OP permits the following uses in lands designated as Hazard Lands:

> *"The use of Hazard Lands will be restricted to agriculture, conservation, forestry, parks, other passive outdoor recreational uses, buildings or structures intended for flood or erosion control or are normally associated with a watercourse protection or bank stabilization, for essential public services and for other uses normally associated with shorelines such as docks, boathouses and marina facilities."*

S. 2.2 of the OP indicates that development is not permitted in Natural Heritage Features, including Woodlands, or on adjacent lands (120 m) unless an Environmental Impact Study (EIS) demonstrates that there will be no negative impacts on the features or their functions.

TOWNSHIP OF SOUTHWOLD ZONING BYLAW NO. 2011-14

Section 3.4 of the Township of Southwold Zoning Bylaw No. 2011-14 describes restrictions on development in Natural Areas and Adjacent Lands as such:

> *"Natural Areas and Adjacent Lands are approximately illustrated on Schedule A to this By-law. No new buildings or structure permitted by the applicable zone shall be erected in a Natural Area or Adjacent Land unless an Environmental Impact Statement demonstrates that there will be no negative impacts on Natural Areas or Provincially Significant Wetlands. The scope and content of the Environmental Impact Statement shall be specified by the Township in consultation with the Ministry of Natural Resources or its delegate."*

CONSERVATION AUTHORITIES ACT, 1990

The Conservation Authorities Act (CAA) grants each of Ontario's 36 Conservation Authorities (CA) the authority to make regulations within the areas under their respective jurisdictions (S. 28). O. Reg 97/04 of the CAA establishes necessary criteria for regulations to be established by each CA under this clause. O. Reg 181/06 is developed by the Kettle Creek Conservation Authority (KCCA) to meet the requirements of O. Reg 97/04 within the lands under its jurisdiction, including the Dodd's Creek Watershed. Section 2(2) of O. Reg 97/04 describes the jurisdiction of the KCCA as follows:

> *"All areas within the jurisdiction of the Authority that are described in subsection (1) are delineated as the "Regulation Limit" shown on a series of maps filed at the head office of the Authority under the map title "Ontario Regulation 97/04: Regulation for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses". O. Reg. 62/13, s. 1 (3)."*

Under S.3 (1) of O. Reg 181/06, KCCA may grant permission to develop within regulation limits if, in its opinion, the control of flooding, erosion, dynamic beaches, pollution or the conservation of land will not be affected by the development.

ENDANGERED SPECIES ACT, 2007

The provincial Endangered Species Act (ESA) prohibits the killing, harming, harassing, capturing or taking of a living member of a species listed as Threatened, Endangered or Extirpated by the Species at Risk in Ontario (SARO) list (O. Reg 230/08) (S. 9), or the damage to habitat of similarly designated species (S. 10), except where a permit is issued under S. 17(2) of the same act or the Activity is registered under the Species at Risk Registry (the Registry), which was introduced alongside O. Reg 242/08 of the ESA in 2014. O. Reg 242/08 provides a regulatory framework for the registry process, which exempts activities that meet a defined set of criteria, as outlined within the regulation, from the ESA S.17(2) permit process. Not all species or activities are eligible for the Registry.

MIGRATORY BIRDS CONVENTION ACT, 1994

The federal Migratory Birds Convention Act (MBCA) is intended to conserve and protect migratory birds and their nests (S.4). Under S. 12(1) of the MBCA, regulations necessary to uphold the purpose of the act may be made by the Governor in Council. These regulations may be found under the Migratory Bird Regulations (C.R.C., c. 1035). Section 6 of the regulations prohibits the disturbance, destruction or taking of a nest, egg, or nest shelter of a migratory bird. Nest disturbance during the course of vegetation clearing may be considered as "incidental take" under the MBCA. Clearing of onsite vegetation needs to be avoided during the breeding bird season (May 1 through July 31) to protect nests under the MBCA. If clearing is necessary during this window, a nest survey, as required by the Canadian Wildlife Service (CWS), will need to be conducted. This survey must occur no more than 72 hours before any clearing activity. If the proposed clearing is not completed within 72 hours of the nest search, the search must be repeated. If a nest is found, a no-touch buffer surrounding the nest (the width of which is determined by the species' nesting requirements) will need to be enforced until the young have naturally fledged.

COUNTY OF ELGIN WOODLANDS CONSERVATION BY-LAW NO. 05-03

The County of Elgin Woodlands Conservation By-law outlines prohibitions on tree and woodland clearing, and offers numerous conditions under which an exemption may be granted. These exemptions include the issuance of permits under Schedules B or F of the document, or general exemptions applied under various acts and authorities as outlined in S. 3 of the by-law.

SURVEY METHODS AND OBJECTIVES

Natural Heritage Features were first identified for each site via background review. The following sources were consulted:

- Natural Heritage Information Centre (NHIC) Biodiversity Explorer Database (2015) (Attachment 3);
- Species at Risk in Ontario List (database) (MNRF, 2015);
- Atlas of the Mammals of Ontario (Dobbyn, 1994);
- Atlas of the Breeding Birds of Ontario, 2001-2005 (Cadman et al., 2007);
- Ontario Reptile and Amphibian Atlas (Ontario Nature, 2015);
- Land Information Ontario (LIO) Database (Attachment 4);
- Township of Southwold Zoning Bylaw No. 2011-14 and Schedule A Map 4;
- KCCA Regulation 97/04 Map D3;
- KCCA Watershed Report Card (2013);
- Ontario Regulation 181/06 (2006) under the Conservation Authorities Act (1990);
- Draft Talbotville/Ferndale Master Servicing Plan Municipal Class EA (Stantec, 2014); and,
- Correspondence with Aylmer District Ministry of Natural Resources and Forestry (MNRF).

Following the background review, both sites were visited on November 26, 2015 in order to confirm the presence and location of Natural Heritage Features, identify potential Species at Risk (SAR) habitat not included in existing records review, and identify potential additional constraints.

RESULTS

The following SAR have the potential to occur in the vicinity of the proposed facility based on background review:

Common Name	Latin Name	ESA Status	Record Source	Comments
Acadian Flycatcher	*Empidonax virescens*	Endangered	KCCA Watershed Report Card (2013)	No Maple and Beech in deciduous forest on South Site No Suitable habitat on North Site
Bobolink	*Dolichonyx oryzivorus*	Threatened	Stantec, 2014	Potentially suitable habitat in hay field on South Site No suitable habitat on North Site
Monarch	*Danaus plexippus*	Special Concern	Stantec, 2014	No significant populations of milkweed are likely on either site.
Eastern Meadowlark	*Sturnella magna*	Threatened	Stantec, 2014	Potentially suitable habitat in hay field on South Site No suitable habitat on North Site
American Badger	*Taxidea taxus*	Endangered	Stantec, 2014	No confirmed sightings in Elgin County since 1979; unlikely to be present on either site (Ontario American Badger Recovery Team, 2010).

Common Name	Latin Name	ESA Status	Record Source	Comments
False rue-anemone	*Enemion biternatum*	Threatened	Stantec, 2014; A. Fleischhauer (District Planner, MNRF) pers. Comm. November 30, 2015	Potentially suitable habitat in woodland riparian area of Dodd's Creek adjacent to South Site No suitable habitat on North Site
Crooked-stem aster	*Symphyotrichum prenanthoides*	Special Concern	Stantec, 2014	Potentially suitable habitat in woodland riparian area of Dodd's Creek adjacent to South Site No suitable habitat on North Site
Eastern Small-footed Bat	*Myotis leibii*	Endangered	None	No large snags or cavity trees (no suitable roost habitat) on South Site No suitable habitat on North Site
Little Brown Myotis	*Myotis lucifugus*	Endangered	None	No large snags or cavity trees (no suitable roost habitat) on South Site No suitable habitat on North Site

Common Name	Latin Name	ESA Status	Record Source	Comments
Spoon-leaved Moss	*Bryoandersonia illecebra*	Endangered	A. Fleischhauer (District Planner, MNRF) pers. Comm. November 30, 2015	Suitable habitat is present in riparian woodland at Dodd's Creek on South Site. No suitable habitat on North Site.
Barn Swallow	*Hirundo rustica*	Threatened	A. Fleischhauer (District Planner, MNRF) pers. Comm. November 30, 2015	Potential category 3 habitat on North and South sites

NORTH SITE

The North Site is zoned CM1 (Commercial-Industrial) by the *Township of Southwold Zoning Bylaw No. 2011-14*, and is designated Industrial by *the Township of Southwold Official Plan Schedule A-2*. The site was a flat, agricultural row crop on the field survey date. A drainage channel ran along the southern site boundary, with a Canadian National (CN) railway running parallel and directly to the south of the channel. The drainage channel was occupied by cattails, goldenrods, common reed, and other wet meadow/marsh species. A complete botanical inventory was not taken on site. The channel emptied into a tributary of Dodd's Creek located east of the site boundary. The floodplain of this tributary is regulated by KCCA; however the entire North Site is located outside of the Regulation Limit.

Barns suitable for Barn Swallow nesting may be located between 120 m and 200 m of the site. The general habitat description for Barn Swallow (MNRF, n.d.) indicates that this may qualify a portion of the site as Category 3 Barn Swallow habitat. Category 3 habitat has a high tolerance to disturbance (MNRF, n.d.). The proposed facility is not considered incompatible with Barn Swallow habitat protection, as it will not fragment existing foraging areas or destroy nesting sites.

The site characteristics are not consistent with habitat descriptions for any other SAR identified by background review.

There are no significant natural features identified within the site boundary, and site characteristics are not consistent with any significant habitat descriptions provided in the Natural Heritage Reference Manual (MNRF, 2010).

Natural heritage constraints for this site are limited to the potential for residual effects on the Dodd's Creek watershed if the current drainage pattern is altered or water quality is impacted at the drainage channel on site. This effect is considered to be mitigable through facility design and sediment and erosion control measures.

SOUTH SITE

The South Site is zoned as a Natural Area and Adjacent Lands by the *Township of Southwold Zoning Bylaw No. 2011-14*, and is located within the KCCA Regulation Limit. The site is a small, flat shelf located within a steeply sloped valley leading to Dodd's Creek. Access to the site was through a steeply sloped unpaved driveway connected to Talbotville Gore Road. An agricultural hay crop was located at the southern site boundary; the balance was wooded. A section of Dodd's Creek is located within 120 m of the southern site boundary. Under the Ecological Land Classification (ELC) system (Lee at al., 1998), the woodland on site was characterized as a Dry-Fresh Basswood Deciduous Forest (FODM4-9), and the Dodd's Creek riparian area was characterized as a Fresh-Moist Deciduous Woodland (WODM5).

The Township of Southwold Official Plan (OP) Schedule A-2 designates this site as Residential, Schedule B (2013) designates a portion of the Site as Woodlands (4 ha+), and Schedule B-1 designates the site as Hazard Lands.

Map 2, included in the Official Plan Schedules as *Map 4-6 of the Kettle Creek Source Protection Area Draft Assessment Report (2009)*, designates a portion of the site as a Significant Groundwater Recharge Area with a vulnerability score of 2. Map 4, included in the Official Plan Schedules as

Map 4-1 of the Kettle Creek Source Protection Area Draft Assessment Report (2009), indicates that the site's aquifer is considered to have low vulnerability.

The South Site contained suitable habitat for Eastern Meadowlark, Bobolink, False rue-anemone, Spoon-leaved moss and Crooked-stem aster. Bobolink and Eastern Meadowlark are listed as Threatened by the SARO list and are afforded protection under the ESA. Consequently, they receive protection for individuals as well as general habitat protection. The development may be eligible for exemption from permit requirements under Section 17 of the ESA if it meets eligibility requirements under Ontario Regulation 242/08 for Bobolink and Eastern Meadowlark. Otherwise, a permit under Section 17(2)(c) of the ESA will be required if impacts are anticipated to either species or their habitats.

Potential habitat for False rue-anemone (Threatened) and Spoon-leaved moss (Endangered) was located along the Dodd's Creek shoreline. A permit under Section 17(2)(c) of the ESA will likely be required if either species is impacted by the proposed project. Crooked-stem Aster is listed as Special Concern, and does not receive mandated habitat protection under the ESA.

Barns suitable for Barn Swallow nesting may be located within 120 m and 200 m of the site. The General habitat description for Barn Swallow (MNRF, n.d.) indicates that this may qualify a portion of the site as Category 3 Barn Swallow habitat. Category 3 habitat has a high tolerance to disturbance (MNRF, n.d.). The proposed facility is not considered incompatible with Barn Swallow habitat protection, as it will not fragment existing foraging areas or destroy nesting sites.

CLOSING

The North Site does not appear to be located in any regulated lands based on the current study. It is not anticipated the proposed facility will have any impacts to SAR or SAR habitat. Constraints related to locating the Facility on this parcel are expected to be related to potential disturbance to the Dodd's Creek watershed as a result of altered drainage patterns or decreased water quality at the drainage channel on the southern site boundary.

The South Site is located within the KCCA Regulation Limit, and will likely require permission from the Conservation Authority under O. Reg 181/06, S. 3 (1) prior to development. It is also zoned as a Natural Area and Adjacent Land by the *Township of Southwold Zoning Bylaw No. 2011-14*. There is potential for significant impacts to Dodd's Creek at this location, as the proposed facility would be located within the steep surrounding valley.

Suitable habitat was present for Bobolink and Eastern Meadowlark, both of which are afforded protection under the ESA. If the proposed facility were to impact either or both of these species, an overall benefit permit under Section 17(2)(c) of the ESA will have to be obtained or, if eligible, the activity will have to be registered under the SAR Registry (O. Reg 242/08). Either option would require habitat compensation and maintenance/monitoring commitments from the applicant. Projects may be registered under the SAR Registry at any time, but two conditions must be met prior to the onset of the activity: First, a habitat management plan must be prepared by a person(s) knowledgeable in the legislation and biological needs of the species for which the activity is being registered; and a Confirmation of Registration must be issued by MNRF. Confirmations are usually issued within 15 days of submitting the Notice of Activity through the SAR Registry.

Potential habitat for False rue-anemone and Spoon-leaved moss was also located along the Dodd's Creek shoreline within 120 m of the site boundary. A permit under Section 17(2)(c) of the ESA would likely be required if the proposed facility was anticipated to impact either of these species. MNRF will attempt to acknowledge receipt and provide comment on an ESA 17(2)(c) permit application within 60 days of receiving it. Once the application is considered complete and agreeable terms are reached between the MNRF and proponent, the MNRF will strive to issue the permit within 3 months. This timeline is variable based on MNRF workload, the complexity of the overall benefit proposal, and project specific details.

Both sites contain vegetation suitable for use by breeding and/or nesting birds. The sites are located near the boundary of nesting zones C1 and C2, whose nesting calendars extend from approximately March 17 through August 29 (EC, 2014). All vegetation clearing should take place outside of this timing window in order to minimize impacts to migratory birds and avoid contravention of the MBCA and its regulations.

Permitting requirements can be refined as Natural Heritage Features and vegetation and wildlife species present on site are confirmed. To this end, Attachment 5 presents a recommended survey effort for the 2016 field season. Please note that survey requirements or recommendations may change at any time up to the issuance of permits, either as new features are identified, as new information becomes available, or as regulations are updated.

This memorandum was prepared by Stantec for the account of The Township of Southwold. The opinions contained within are based on conditions and information existing at the time of writing and do not take into account any subsequent changes. While the information presented is based on the best available resources at the time of writing, this memo is intended to inform the decision-making process as part of the Class-EA and is not represented as being complete or accurate for legal purposes. Stantec does not, expressly or otherwise, make legal recommendations to the client or any third party.

Please do not hesitate to contact the undersigned with any questions or concerns related to this memorandum.

STANTEC CONSULTING LTD.

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Attachment:
1. Aerial Image of North Site (field observations overlaid)
2. Aerial Image of South Site (field observations overlaid)
3. NHIC Results Map
4. LIO Results Map
5. Survey Recommendations

c. Stephanie Bergman, Planner

References

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Talbotville WWTP Class EA
Constraints Memo - Recommended Surveys

Survey	Recommended Effort	Timing	Purpose
Botanical Inventory	Two visits, site walks and quadrat assessments	Spring and Summer	Informs habitat descriptions, determines presence of rare/protected species
False Rue-anemone Targeted Survey	Transects in suitable habitat	Late April-May	Determines presence/absence and informs potential permitting requirements
Spoon-leaved moss Targeted Survey	Transects in suitable habitat	Spring/Summer	Determines presence/absence and informs potential permitting requirements
Breeding Birds	Three surveys, including transects and point counts across study area	June and July	Determines habitat useage by bird species, may have implications from the Migratory Birds Act and ESA
Bobolink and Eastern Meadowlark Targeted Survey	Three surveys, including transects and point counts across study area	June and July	Determines presence/absence and informs potential permitting requirements
ELC Confirmation	One site visit, site walks and quadrat assessments	Spring or Summer	Confirms ELC categorization from fall 2015, categorizes habitat polygons present
General Wildlife and Wildlife Habitat	Transects of the entire study area	During all other surveys	Identifies undocumented habitat features, rare species or vegetation communities, informs impact assessment
Aquatic habitat and fish	TBD*	TBD*	Identifies aquatic habitat and species that may be impacted by the proposal

*Survey parameters should be determined by expert(s) in aquatic ecology and permitting requirements

Appendix 8.1

Assimilative Capacity Study

Talbotville WWTP Class EA Assimilative Capacity Study

FINAL REPORT

Prepared for:
Township of Southwold
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Prepared by:
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FILE 165500796

December 1, 2015

Sign-off Sheet

This document entitled Talbotville WWTP Class EA Assimilative Capacity Study was prepared by Stantec Consulting Ltd. ("Stantec") for the account of Township of Southwold (the "Client"). Any reliance on this document by any third party is strictly prohibited. The material in it reflects Stantec's professional judgment in light of the scope, schedule and other limitations stated in the document and in the contract between Stantec and the Client. The opinions in the document are based on conditions and information existing at the time the document was published and do not take into account any subsequent changes. In preparing the document, Stantec did not verify information supplied to it by others. Any use which a third party makes of this document is the responsibility of such third party. Such third party agrees that Stantec shall not be responsible for costs or damages of any kind, if any, suffered by it or any other third party as a result of decisions made or actions taken based on this document.

Prepared by Jim Perrone
(signature)

Jim Perrone, P. Eng.

Reviewed by Cam Gorrie
(signature)

Cameron Gorrie, P.Eng.

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LIST OF APPENDICES

Executive Summary

Stantec Consulting Ltd. (Stantec) was retained by the Township of Southwold to provide consulting services for an Assimilative Capacity Study for the proposed Talbotville WWTP. The Township of Southwold has proposed to construct a WWTP to serve the existing needs and future growth requirements for the Township of Southwold. The Talbotville WWTP will provide treatment of residential wastewater prior to discharge to Dodd Creek.

Water quality sampling was undertaken to obtain receiving water quality data for the Auckland Drain and Dodd Creek. Sampling results demonstrate elevated TSS and TP concentrations in Dodd Creek as well as in the Auckland Drain. Total ammonia-N concentrations are consistently low while elevated nitrate-N concentrations are evident in both receivers. Conductivity is elevated in both Dodd Creek and Auckland Drain, indicating relatively high concentrations of dissolved solids. Results of benthic invertebrate sampling suggest that the water quality of both Dodd Creek and Auckland Drain is impaired.

Using the Log Pearson III Method, a 7Q20 flow rate of 0.0096 m^3/s was calculated for Dodd Creek at Talbotville. The 7Q20 flow rate of 0.0096 m^3/s calculated for Dodd Creek at Talbotville suggests that the initial receivers of effluent for the proposed Talbotville WWTP (i.e, Gilbert Drain and Auckland Drain) run dry during this low flow period. Therefore, dry ditch criteria are the minimum design criteria applicable to the proposed Talbotville WWTP, namely, $CBOD_5$ 10 mg/L, TSS 10 mg/L, TP 0.3 to 0.5 mg/L, total ammonia-N 1 to 3 mg/L, and chlorine absent.

The Talbotville WWTP will have a maximum approved capacity flow rate of 550 m^3/d, with future expansions to 1,250 m^3/d and to 1,750 m^3/d. To verify the potential impact of the discharge on Dodd Creek, where permanent flow is known to occur, effluent limits reflecting dry ditch criteria were applied to the proposed Talbotville WWTP for the initial 550 m^3/d capacity for a 7Q20 flow in Dodd Creek, along with 75th percentile background water quality. However, in consultation with the MOECC, and due to concerns regarding elevated pH in the receiving environment, lower ammonia-N limits have been assigned to the proposed WWTP.

To simulate water quality in Dodd Creek, projected effluent discharge flows and background water quality data were input to a simple mass balance model. The effluent limits and objectives presented in Table E.1 are recommended for the proposed Talbotville WWTP. The limits proposed are valid for the initial build out or an effluent capacity of 550 m^3/d. The effluent limits should be verified and revised as needed upon introduction of additional plant capacity that increases effluent flow rates.

Table E.1 Recommended ECA Effluent Limits and Objectives

Parameter	Effluent Limit	Effluent Objective
$CBOD_5$	10	5
TSS	10	5
Total Phosphorous	0.3	0.2
Total ammonia-N (Non-freezing period)	1.5	1
Total ammonia-N (Freezing Period)	4	3
pH	6.0 to 8.5	6.0 to 8.5
E. Coli	150 organisms per 100 mL	150 organisms per 100 mL

Note:

(a) Non-freezing period represents the period from May 1 through November 30;
(b) Freezing period represents the period from December 1 through April 30

Abbreviations

°C	degrees Celsius
7Q20	seven-day average low flow that can be expected once in 20 years
ACS	assimilative capacity study
BOD	biochemical oxygen demand
$CBOD_5$	carbonaceous biochemical oxygen demand
DO	dissolved oxygen
EA	environmental assessment
ECA	environmental compliance approval
kg/d	kilogram(s) per day
km	kilometre
m^3	cubic metres
m^3/d	cubic metres per day
mg/L	milligrams per litre
MOECC	Ontario Ministry of the Environment and Climate Change
NO_2	nitrite
NO_3	nitrate
pH	acidity or basicity
PO_4	phosphate
PQWO	Provincial Water Quality Objective
PWQMN	Provincial Water Quality Monitoring Network
TKN	total kjeldahl nitrogen
TP	total phosphorus
TSS	total suspended solids

1.0 INTRODUCTION

Stantec Consulting Ltd. (Stantec) was retained by the Township of Southwold to provide consulting services for an Assimilative Capacity Study (ACS) of the proposed Talbotville WWTP. The Township of Southwold proposes to construct a WWTP to serve the existing needs and future growth requirements for the community of Southwold. The Talbotville WWTP will provide treatment of residential and commercial wastewater prior to discharge to Dodd Creek.

1.1 OBJECTIVE

The general objectives of the assimilative capacity study are to:

- Characterize the receiving water quantity and quality;
- Select and configure an appropriate water quality model for Dodd Creek;
- Apply the model to several scenarios which involve different rates of effluent discharge and background conditions;
- Assess the potential impact of the discharge on Dodd Creek, including downstream users; and
- Make recommendations on effluent limits.

Following discussions with the MOECC, it was concluded that available water quality data for Dodd Creek are not adequate to characterize the background water quality of Dodd Creek. Therefore, an *in-situ* monitoring program was implemented. Dodd Creek and Auckland Drain were sampled on a seasonal basis. The water quality parameters of interest included total ammonia, total suspended solids (TSS), total kjeldahl nitrogen (TKN), and anions (such as NO_2, NO_3, and PO_4). *In-situ* measurements of temperature, pH, conductivity, and dissolved oxygen (DO) were also taken at each sampling station along the creek.

1.2 THE COMMUNITY OF SOUTHWOLD

The Township of Southwold (Southwold) is a small, rural municipality immediately west of the City of St. Thomas (**Figure 1.1, Appendix A**). The Township has completed a Master Servicing Plan (MSP) for the provision of water and wastewater servicing and stormwater management under the Municipal Class Environmental Assessment (Class EA) process for the Talbotville and Ferndale settlement areas.

There is no municipal wastewater collection or treatment infrastructure within Talbotville. Existing development within the settlement area is serviced by private on-site septic systems. There is also no municipal wastewater treatment infrastructure within Ferndale, however wastewater flows generated by existing development is conveyed via municipal sanitary sewers to the St. Thomas WWTP.

1.3 PROPOSED TALBOTVILLE WWTP

The preferred alternative for wastewater servicing within Talbotville is to construct a new municipally owned and operated wastewater treatment plant. The initial build out for the plant is designed for a capacity of 550 m^3/d, with full build out in subsequent phases of 1,250 m^3/d and then ultimately 1,750 m^3/d (if Ferndale is included).

1.4 DODD CREEK

The Dodd Creek Watershed is located in southeastern Ontario and has a drainage area of 133 km^2. It is a sub-catchment to the larger Kettle Creek which covers a drainage area of approximately 520 km^2, running 80 km to the north shore of Lake Erie at Port Stanley (**Figure 1.2, Appendix A**). The creek flows from the headwaters down to the south and is Kettle Creek's largest tributary representing approximately 25% of the greater watershed.

The Dodd Creek basin contains portions of Southwold, Middlesex Centre, London, St. Thomas, and Central Elgin municipalities. The land use is primarily rural farmland with 63% row crops, 16% small grains, 11% wildlands, 5% legumes/grasses, 3.5% urban, 1% other and 0.5% pasture. Soils mainly clay loam (44%), followed by loam (23%), silty loam (10%), fine sandy loam (5%), and bottom land (4%).

A large number of municipal drains create a network across the sub-watershed. Two drains of interest are the Gilbert Drain and the Auckland Drain. One proposed location for the Talbotville WWTP is located on the Gilbert Drain (**Figure 1.3, Appendix A**). The Gilbert Drain runs from the west to the east into the Auckland Drain which flows to the southeast into Dodd Creek.

Long-term goals for water quality in Ontario are based on PWQOs provided in the MOECC publication Water Management – Goals, Policies, Objectives and Implementation Procedures of Ministry of the Environment (MOE, 1994). Procedures used by the MOECC to establish receiving-water based effluent requirements for point source discharges to surface waterbodies are provided in the document Deriving Receiving-Water Based, Point-Source Effluent Requirements For Ontario Waters (MOE, 1994b).

2.0 BACKGROUND DATA

2.1.1 Final Effluent Flow

With respect to effluent flow, the Talbotville WWTP will have a maximum approved capacity flow rate of 550 m^3/d, with future expansions to 1,250 m^3/d and to 1,750 m^3/d.

2.2 DODD CREEK

The following section presents and discusses water quality results in Dodd Creek and Auckland Drain, the receiving waters.

2.2.1 Water Quality

2.2.1.1 2014 *In-Situ* and Grab Sampling

Sampling was conducted by Stantec during the process of this Assimilative Capacity Study to characterize the background water quality of the Auckland Drain and Dodd Creek. This monitoring included sampling upstream of the proposed WWTP outfall locations (**Figure 2.1, Appendix A**), and was performed in conjunction with benthic invertebrate sampling. Grab samples were sent for laboratory analysis of parameters of interest and *in-situ* measurements of temperature, pH, conductivity, and DO were also taken. The parameters analyzed for include TSS, TP, anions (such as NO_2, NO_3, PO_4), and Ammonia-N. Laboratory results are summarized in Table 1 (Appendix B) and were analyzed to generate 75th percentile concentrations for water quality parameters of interest.

Sampling results demonstrate elevated TSS (140 mg/L) and TP (0.36 mg/L) concentrations during a runoff event in Dodd Creek in November 2014 (**Table 1, Appendix B**). TSS and TP concentrations were also elevated in the Auckland Drain, although to a lesser degree, at the time of sampling. Elevated TP concentrations were also noted in Dodd Creek in July, 2015 (0.73 and 1.1 mg/L). TP concentrations were above the PWQO of 0.03 mg/L for all samples in both water bodies. Elevated concentrations of TP appear to coincide with elevated levels of dissolved phosphorus. Total ammonia-N concentrations were consistently below 0.1 mg/L for all samples, while nitrate-N concentrations ranged from 4.82 to 10.8 mg/L in Dodd Creek, and 5.16 to 8.44 mg/L in Auckland Drain. Field pH levels were below 8 for all samples, while lab pH measurements were often above 8. Conductivity is elevated in both Dodd Creek and Auckland Drain, approaching or attaining 1,000 µmhos/cm, which indicates a relatively high concentration of dissolved constituents.

2.2.2 River Flow

The Water Survey of Canada (WSC) maintains an active continuous flow gauging station on Dodd Creek below Paynes Mills (Station 02GC031; 42°47'14" N, 81°16'3" W). Daily flow data for this station were obtained for the 1988 to 2013 period and analyzed to characterize flow in Dodd Creek.

As required by the MOECC document *"Deriving Receiving-Water Based, Point-Source Effluent Requirements for Ontario Waters"*, a 7Q20 flow rate for the receiving water was calculated. The 7Q20 flow is the 7-day average low flow that can be expected once in 20 years. Daily flow data below Paynes Mills were analyzed and pro-rated by drainage area to determine the 7Q20 flow in Dodd Creek at Talbotville. The Log-Pearson III method (Viessman et al., 1989) was used to calculate the 7Q20 flow for Dodd Creek below Paynes Mills (described in Section 2.2.3).

Using the Log Pearson III Method, a 7Q20 flow rate of 0.0096 m^3/s was calculated for Dodd Creek at Talbotville. Having much smaller drainage areas than Dodd Creek, the Auckland Drain and Gilbert Drain likely run dry during the 7Q20 event and perhaps other low flow events of lesser magnitude.

2.2.3 Log Pearson III Method

The Pearson type III distribution is a special case of the gamma distribution, which has wide application in mathematical statistics and has been increasingly used in hydrological studies as a standard method for flood and low flow frequency analysis (Viessman *et al.*, 1989). All three moments about the mean are required to fit the distribution to a particular data set. The fitting technique involves transforming low flows (7-day average low flows in the 7Q20 case) to logarithmic values (i.e., yi = log xi) and finding the mean, standard deviation, and skew coefficients of the logarithms. Low flow magnitudes are then estimated from the equation:

$$\log(Q) = \bar{y} - K_{sy} \qquad \{1\}$$

where Q = low flow magnitude

$\bar{y}$ = mean of the low flow logarithmic values

$_{sy}$ = the standard deviation of the low flow logarithmic values

K = a frequency factor

The frequency factor, K, is literally the number of standard deviations above and below the mean required to attain the probability point of interest. If the skew coefficient, Cs, falls between –1.0 and 1.0, approximate values of frequency factors for the Pearson distribution can be obtained from the following equation:

$$K = \frac{2}{C_s}\left\{\left[\left(z-\frac{C_s}{6}\right)\frac{C_s}{6}+1\right]^3 -1\right\} \qquad \{2\}$$

where $$C_s = \frac{a}{s^3} \qquad \{3\}$$

and $$a = \frac{n}{(n-1)\,(n-2)}\sum_{i=1}^{n}(x_i-\bar{x})^3 \qquad \{4\}$$

where a = the best estimate of the third moment about the mean

n = the number of observations

x_i = the ith logarithmic value; and

$\bar{x}$ = mean of the logarithmic values, which is equivalent to ȳ.

Frequency factors for skew coefficients outside the range of –1.0 to 1.0 can be obtained from Pearson III frequency distribution tables.

2.2.4 Benthic Invertebrate Survey

Stantec conducted a baseline benthic macroinvertebrate survey in Aukland Drain and Dodd Creek in the vicinity of proposed Wastewater Treatment Plant (WWTP) locations. The benthic monitoring program was designed to document existing (baseline) benthic conditions in the vicinity of potential discharge locations from the proposed WWTP for comparison with post-construction conditions. Quantitative benthic macroinvertebrate samples were collected from Aukland Drain on November 25, 2014 and from Dodd Creek on April 15, 2015.

BioMAP water quality indices from the Aukland Drain stations were compared to Creek ratings for watercourses less than 4 m wide. The BioMAP water quality indices from the Dodd Creek stations were compared to Stream ratings for watercourses between 4 m and 16 m wide. BioMAP $WQI_{(d)}$ endpoints were indicative of "impaired" water quality at all six stations. With respect to the qualitative index, half the stations fell within the "impaired" while the other half fell within the "inconclusive" range between impaired and unimpaired water quality. The complete benthic monitoring report is provided as Appendix C.

3.0 WATER QUALITY MODELING

3.1 OVERVIEW OF ANALYSIS

The approach to simulating water quality within Dodd Creek involved the application of a simple mass balance model. Background water quality data for Dodd Creek were used for the model. The specific parameters modeled were:

- TSS
- Total Phosphorus (TP)
- Ammonia

The effluent loading scenarios modeled include low flow receiving water conditions for effluent flow rates of 550 m^3/d, 1,250 m^3/d and 1,750 m^3/d.

The 75th percentile background concentrations and 7Q20 flow rate were applied to the scenarios above. The analysis yielded an overall estimate of the assimilative capacity of the receiving water system.

3.2 WATER QUALITY MODELING RESULTS AND DISCUSSION

3.2.1 Projected Water Quality in Dodd Creek

The 7Q20 flow rate of 0.0096 m^3/s calculated for Dodd Creek at Talbotville suggests that the initial receivers of effluent for the proposed Talbotville WWTP (i.e, Gilbert Drain and Auckland Drain) run dry during this low flow period. Therefore, dry ditch criteria are the minimum design criteria applicable to the proposed Talbotville WWTP, namely, CBOD$_5$ 10 mg/L, TSS 10 mg/L, TP 0.3 to 0.5 mg/L, total ammonia-N 1 to 3 mg/L, and chlorine absent.

To verify the potential impact of this discharge on Dodd Creek, where permanent flow is known to occur, these criteria were applied to the proposed Talbotville WWTP for the initial 550 m^3/d capacity for a 7Q20 flow in Dodd Creek, along with 75th percentile background water quality. The in-stream concentrations of main water quality parameters of interest (ammonia-N, TSS, and TP) were calculated using a simple mass balance. DO modeling was not undertaken as the low levels of CBOD$_5$ and ammonia-N anticipated in the discharge are not projected to have an influence on in-stream DO concentrations.

For an effluent flow rate of 550 m^3/d and an ammonia-N effluent concentration of 3 mg/L, un-ionized ammonia-N concentrations of 0.014 mg/L will be achieved in Dodd Creek at full mixing. This concentration is below the PWQO of 0.0165 mg-N/L. The 75th percentile background temperature and field pH of 21.9 °C, and 7.4, respectively, were applied in the analysis. Although a greater number of lab pH readings were obtained, pH measurements tend to increase substantially in comparison to field pH. Therefore, field pH was applied. When winter conditions are considered, for a creek temperature of 8.2 °C (the maximum measured outside of the summer period) and a pH of 7.4, effluent ammonia-N concentrations of 10 mg/L will produce un-ionized ammonia-N levels of 0.016 mg/L, which is below the PWQO of 0.0165 mg-N/L.

Since the 75th percentile background TP concentration of 0.73 is much greater than the dry ditch criteria for effluent of 0.3-0.5 mg/L, any effluent TP concentration selected from this range will decrease the receiving water concentration. For an effluent TP of 0.3 mg/L and an effluent flow rate of 550 m^3/d, TP concentrations in Dodd Creek are calculated to fall to 0.56 mg/L. Similarly, for an effluent TSS of 10 mg/L and an effluent flow rate of 550 m^3/d, TSS concentrations in Dodd Creek are calculated to fall to 23 mg/L (as compared to 75th percentile concentrations of 32 mg/L).

For effluent flow rates of 1,250 m^3/d, and 1,750 m^3/d, and an ammonia-N effluent concentration of 3 mg/L, un-ionized ammonia-N concentrations of 0.020 mg/L, and 0.023 mg/L, respectively will be achieved in Dodd Creek at full mixing. These concentrations are above the PWQO of 0.0165 mg-N/L. Lowering the ammonia-N effluent concentration to 2 mg/L decreases the projected un-ionized ammonia-N concentrations to 0.014 mg/L, and 0.015 mg/L, respectively. These predicted concentrations do not take into account the potential for in-stream nitrification which may take place in Gilbert Drain and Auckland drain prior to effluent entering Dodd Creek. When considering the winter period, effluent ammonia-N levels would need to be maintained at of below 6 mg/L to ensure un-ionized ammonia-N concentrations below the PWQO for effluent flow rates of 1,250 m^3/d (0.014 mg-N/L), and 1,750 m^3/d (0.016 mg-N/L).

At effluent flow rates of 1,250 m^3/d, and 1,750 m^3/d, TSS levels in Dodd Creek are projected to fall to 0.47 mg/L, and 0.44 mg/L, respectively. Similarly, TSS levels are projected to fall to 19 mg/L, and 17 mg/L, respectively.

3.2.2 Discussion

Although there is uncertainty regarding the existing water quality of Auckland Drain and Dodd Creek, benthic invertebrate sampling suggests that water quality conditions are impaired in both of these receivers. The effluent quality criteria to be assigned to the proposed Talbotville WWTP should therefore not exacerbate this condition. Water quality sampling suggests that dry ditch criteria for TSS (10 mg/L) represent lower concentrations than currently experienced in the receiver. Furthermore, water quality sampling suggests that an effluent limit of 0.3 mg/L for TP would ensure that TP concentrations in Dodd Creek do not increase from current levels. The sampling data suggest that the effluent discharge may actually decrease TP concentrations in Dodd Creek during low flow conditions.

Application of an effluent ammonia-N limit of 3 mg/L during the summer period maintains un-ionized ammonia-N concentrations below PWQOs in Dodd Creek for an effluent discharge of 550 m³/d. However, at this effluent limit, increasing plant capacity to1,250 m³/d or 1,750 m³/d may produce un-ionized ammonia-N concentrations above PWQOs. Similarly, during the winter period, application of an effluent ammonia-N limit of 10 mg/L may be acceptable for an effluent discharge of 550 m³/d, but may produce exceedance of PWQOs at greater effluent flows.

In consultation with the MOECC, and due to concerns regarding pH levels in the receivers, ammonia-N limits were derived based on summer temperatures of 25°C and a pH of 8.2, as well as winter temperatures of 10°C and a pH of 8.2. No potential for effluent dilution was allocated for these scenarios. Under such conditions, 8.25% un-ionized ammonia-N is present in summer, and 2.86% in the winter. Lowering the summer ammonia-N effluent limit to 1.5 mg/L with an associated effluent objective of 1 mg/L produces a maximum un-ionized ammonia-N concentration of 0.12 mg/L at the limit, and 0.083 mg/L at the objective. MOECC has historically considered 0.1 mg/L un-ionized ammonia-N as non-toxic, therefore, the Talbotville WWTP effluent would be below this threshold the majority of the time within the dry ditch (Gilbert Drain and Auckland Drain). For the winter conditions, a 4 mg/L limit and 3 mg/L objective would achieve 0.11 mg/L un-ionized ammonia-N at the limit, and 0.086 mg/L at the objective, once again below the 0.1 mg/L un-ionized ammonia-N threshold the majority of the time. As previously discussed, once joining Dodd Creek, concentrations would fall further due to dilution as well as some in-stream nitrification that would take place during the summer.Therefore, the effluent limits and objectives presented in **Table 2 (Appendix B)** are recommended for the proposed Talbotville WWTP. The effluent limits generally reflect dry ditch criteria which were verified to ensure compliance with MOECC policies for the receiver.

4.0 SUMMARY AND CONCLUSION

Stantec Consulting Ltd. (Stantec) was retained by the Township of Southwold to provide consulting services for an Assimilative Capacity Study (ACS) of the proposed Talbotville WWTP. An *in-situ* water quality monitoring program was implemented and Dodd Creek and Auckland drain were sampled on a seasonal basis. In addition, Stantec conducted a baseline benthic macroinvertebrate survey in Aukland Drain and Dodd Creek in the vicinity of a proposed WWTP.

Sampling results demonstrate elevated TSS and TP concentrations in Dodd Creek as well as the Auckland Drain, although to a lesser degree. Total ammonia-N concentrations are consistently low while elevated nitrate-N concentrations are evident in both receivers. Conductivity is elevated in both Dodd Creek and Auckland Drain, indicating relatively high concentrations of dissolved solids. Results of benthic invertebrate sampling suggests that the water quality of both Dodd Creek and Auckland Drain is impaired.

The effluent limits recommended for the proposed Talbotville WWTP reflect dry ditch criteria which were verified to ensure compliance with MOECC policies for the receiver. The limits proposed are valid for the initial build out or an effluent capacity of 550 m^3/d. These effluent limits should be verified and revised as needed upon introduction of additional plant capacity that increases effluent flow rates. Further monitoring of the receiving environment should be undertaken to support adoption of the effluent criteria proposed and to determine the need for any alterations to the criteria.

5.0 LITERATURE CITED

MOE. 1994a. Water Management – Goals, Policies, Objectives and Implementation Procedures of Ministry of the Environment. Ministry of Environment and Energy, July, 1994.

MOE. 1994b. Deriving Receiving-Water Based, Point-Source Effluent Requirements For Ontario Waters. Ministry of Environment and Energy, July, 1994.

Viessman, W. Jr., G. L. Lewis, and J. W. Knapp. 1989. Introduction to Hydrology, 3rd edition. Harper Collins Publishers Inc., New York, New York.

Appendix A FIGURES

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Revised: 2014-08-07 By: kbuchanan

August 2014
165500796

Stantec

Legend

▭ Settlement Area/Study Area

Client/Project

Township of Southwold
Talbotville & Ferndale Master
Servicing Plan

Figure No.

1.1

Title

Study Area

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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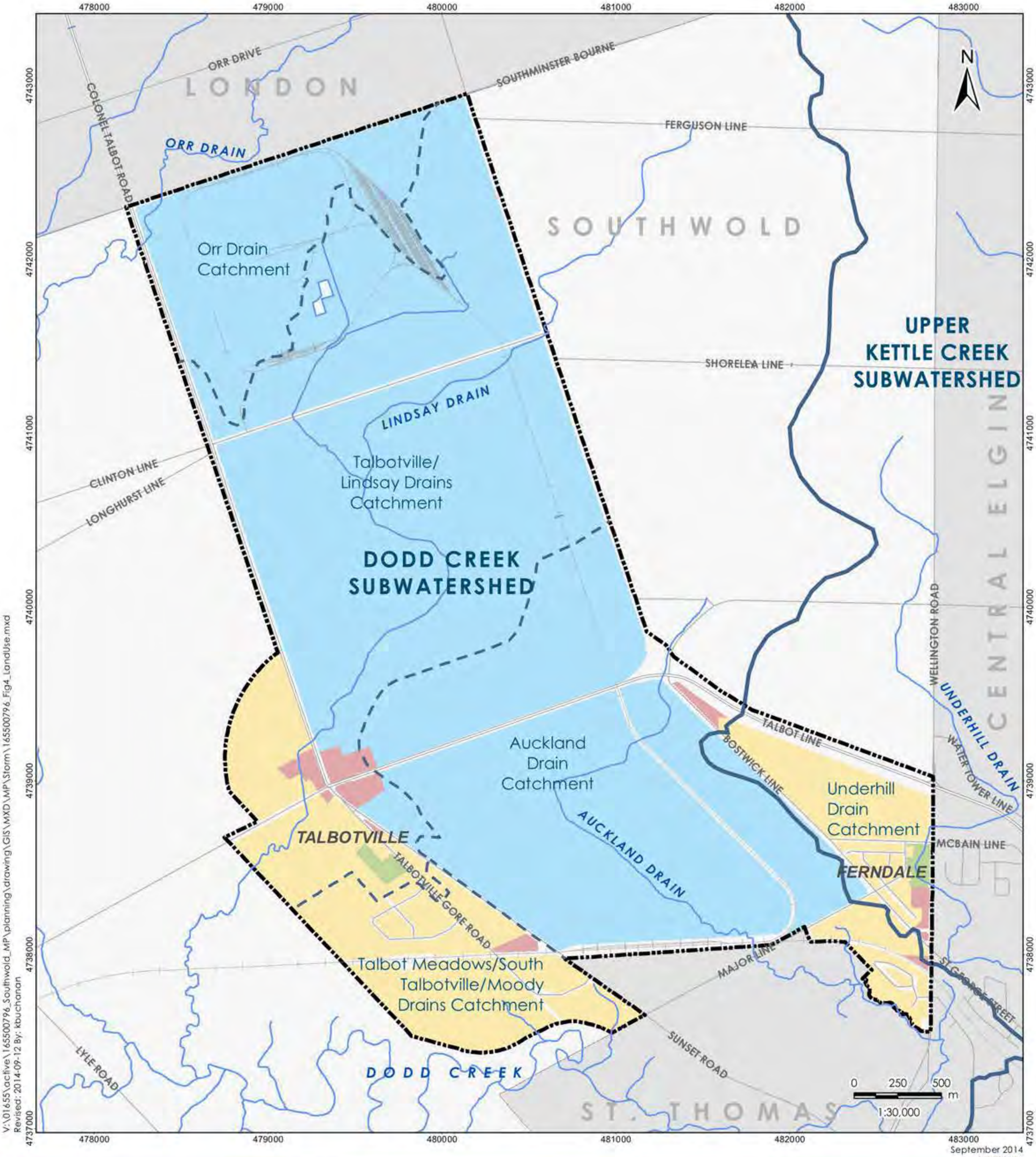

Stantec

Legend

- Study Area
- Subwatershed
- Catchment Boundary

Official Plan Proposed Land Use

- Residential
- Industrial
- General Commercial
- Open Space

Notes

1. Coordinate System: NAD 1983 UTM Zone 17N
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Township of Southwold
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Master Servicing Plan

Figure No.

1.2

Title

Proposed Conditions Drainage Plan

Stantec

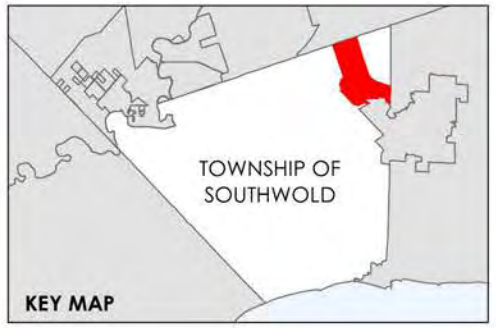
Legend

▭ Settlement Area/Study Area

▲ Benthic Sampling Station

➡ Flow Direction

◌ Proposed WWTP Location



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May 2015
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Client/Project

Township of Southwold
Talbotville/Ferndale
Master Servicing Plan

Figure No.

2.1

Title

Monitoring Locations

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Revised: 2015-05-27 By: kbuchanan

Appendix B TABLES

Table 1 Grab Sampling Data for Dodd Creek and Auckland Drain Creek near Proposed Talbotville WWTP Discharge

Parameter	Units	RDL	PWQO	Dodd Creek						Auckland Drain			75th Percentile	
				11/25/ 2014	12/10/ 2014	4/15/ 2015	4/15/ 2015	7/14/ 2015	7/14/ 2015	11/25/ 2014	4/15/ 2015	7/14/ 2015	Dodd Creek	Auckland Drain
Total Ammonia-N	mg/L	0.050		0.077	ND	0.061	0.067	ND	ND	ND	0.054	0.055	0.066	0.055
TKN	mg/L	0.10		1.90	0.73	1.20	1.30	1.30	1.40	1.30	1.10	0.64	1.40	1.20
Orthophosphate (P)	mg/L	0.004		0.140	0.064	0.070	0.100	0.580	0.830	0.180	0.013	0.060	0.580	0.120
Total Phosphorus	mg/L	0.020	0.03	0.360	0.065	0.100	0.140	0.730	1.100	0.280	0.043	0.072	0.730	0.176
TSS	mg/L	1		140	5	18	32	29	29	34	4	12	32	23
Nitrite (N)	mg/L	0.010		0.032	0.018	0.013	ND	0.045	0.038	0.025	ND	0.050	0.038	0.038
Nitrate (N)	mg/L	0.10		4.95	4.99	4.82	5.26	10.80	10.60	8.44	5.16	5.89	10.60	7.17
Nitrate + Nitrite	mg/L	0.10		4.98	5.01	4.84	5.26	10.80	10.60	8.46	5.16	5.94	10.60	7.20
Temperature	°C					8.2	7.9	22.0	21.9	4.6		19.0	21.9	15.4
Lab pH	pH		6.5-8.5	7.96	8.21	8.23	8.19	8.30	8.35	7.87	8.46	8.11	8.30	8.29
Field pH	pH		6.5-8.5			7.41	7.35			7.86			7.40	7.86
Dissolved Oxygen*	mg/L		4-7			13.30	13.10	7.17	7.47	14.70		8.64	7.40	10.16
Conductivity	umho/cm	1			900	834	837	930	880	516		1,000	893	879
Escherichia coli	CFU/100mL	10	100**	780	ND	50	110	250	900	220	ND	6,700	648	3,460

Notes:

RDL = Reportable Detection Limit
ND = Not detected
* Percentile values represent the 25th percentile for DO
** PWQO is for the geometric mean of at least 5 samples
Shaded values indicate results above the PWQO

Table 2 Recommended ECA Effluent Limits and Objectives

Parameter	Effluent Limit	Effluent Objective
$CBOD_5$	10	5
TSS	10	5
Total Phosphorous	0.3	0.2
Total ammonia-N (Non-freezing period)	1.5	1
Total ammonia-N (Freezing Period)	4	3
pH	6.0 to 8.5	6.0 to 8.5
E. Coli	150 organisms per 100 mL	150 organisms per 100 mL

Note:

(a) Non-freezing period represents the period from May 1 through November 30;
(b) Freezing period represents the period from December 1 through April 30

Appendix C BENTHIC MONITORING PROGRAM REPORT

2015 Benthic Monitoring Program In Support of the Proposed Talbotville Wastewater Treatment Plant

Prepared for:

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File No. 165500796
October 23, 2015

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1.0 INTRODUCTION

This report documents Stantec Consulting Ltd.'s (Stantec's) findings for a baseline benthic macroinvertebrate survey in Aukland Drain and Dodd Creek in the vicinity of a proposed Wastewater Treatment Plant (WWTP). The WWTP will service the community of Talbotville, Ontario with the potential to service Ferndale as well. The 2015 benthic survey was a requirement of the Ontario Ministry of the Environment and Climate Change (MOECC) as a supplement to the Southwold Assimilative Capacity Study of Aukland Drain and Dodd Creek. This benthic monitoring program was designed to document existing (baseline) benthic conditions in the vicinity of potential discharge locations from the proposed WWTP for comparison with post-construction conditions.

Benthic macroinvertebrates are small-bodied organisms that live on the bottom substrates of aquatic environments, such as lakes and rivers. They are commonly used as biological indicators of water and habitat quality.

More specifically, macroinvertebrates are good indicators of overall water quality and environmental conditions for the following reasons (Griffiths, 1998):

- They are abundant in all types of aquatic systems;
- They are readily identified by experienced taxonomists;
- They usually remain in a localized area, as they have restricted mobility and specific habitat preferences / requirements;
- They are continuously subjected to all conditions of the local environment throughout their life cycle; and
- They integrate the effects of all pollutants and environmental conditions over time and, therefore, provide a holistic measure of water quality.

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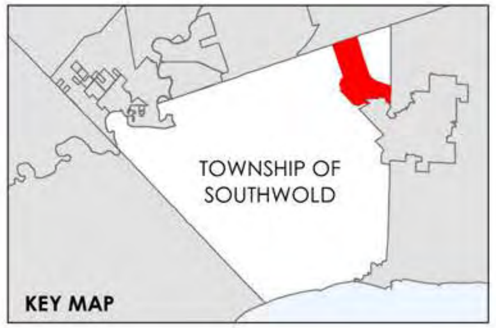
Revised: 2015-05-27 By: kbuchanan

Stantec

Legend

▭ Settlement Area/Study Area
▲ Benthic Sampling Station
→ Flow Direction
◌ Proposed WWTP Location



Notes

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May 2015
165500796

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Township of Southwold
Talbotville/Ferndale
Master Servicing Plan

Figure No.

1

Title

Benthic Sampling Station Locations

2.0 METHODS

2.1 BIOMONITORING STATION LOCATIONS

The study area is located within the Dodd Creek watershed, near St. Thomas, Ontario and includes Aukland Drain; one of its tributaries (Figure 1). Field samples were collected at six locations (Table 1) organized as paired upstream reference and downstream exposure stations at each potential outfall:

1. Aukland Drain, upstream of a proposed WWTP outfall option,
2. Aukland Drain, downstream of a proposed WWTP outfall option,
3. Dodd Creek, upstream of its confluence with the Aukland Drain,
4. Dodd Creek, downstream of its confluence with the Aukland Drain,
5. Dodd Creek, upstream of a proposed WWTP outfall option, and
6. Dodd Creek, downstream of a proposed WWTP outfall option.

Sampling locations were chosen in an effort to minimize variation in habitat between paired stations. Riffle habitats with cobble, gravel and sand substrates and moderate to fast water velocity were targeted for each sampling station.

Table 1: Summary of Benthic Macroinvertebrate Sampling Station Locations

Station	GPS UTM Easting Coordinates (NAD 83, Zone 17T)	GPS UTM Northing Coordinates (NAD 83, Zone 17T)	Descriptive Location
Aukland Drain			
1	0481572	4738127	5 m upstream of the proposed WWTP outfall option on Aukland Drain
2	0481716	4738119	185 m downstream of the proposed WWTP outfall option on Aukland Drain
Dodd Creek Confluence with Aukland Drain			
3	0482674	4736744	Dodd Creek, 20 m upstream of its confluence with Aukland Drain.
4	0482634	4736696	Dodd Creek, 60 m downstream of its confluence with Aukland Drain.
Dodd Creek			
5	0480558	4737496	30 m upstream of the proposed WWTP outfall option on Dodd Creek
6	0480640	4737516	55 m downstream of the proposed WWTP outfall option on Dodd Creek

2.2 FIELD SAMPLING

Quantitative benthic macroinvertebrate samples were collected from Aukland Drain on November 25, 2014 and from Dodd Creek on April 15, 2015 using a Surber sampler (area = 0.093 m^2) equipped with a 500 µm mesh bag. Two replicates were collected at each of the six stations and preserved separately in the field in 10% buffered formalin. The following supporting measurements and observations were made at each of the benthic sampling stations: pH, dissolved oxygen, conductivity, water and air temperature, water depth, and water velocity. Substrate and aquatic habitat characteristics were recorded.

2.3 LABORATORY METHODS AND TAXONOMY

The sorting and identification of benthic macroinvertebrates was conducted in Stantec's laboratory in Guelph, Ontario. Samples were stained with Eosin-B and Biebrich Scarlet (Fisher Scientific). Staining facilitates sorting by preferentially staining the organisms so they can be more easily distinguished from the sample debris. The samples were washed in a 500 µm sieve to remove formalin and the remaining sample material was washed from the sieve into a plastic gridded sorting tray. Organisms were sorted from the tray using a 10 - 40x stereomicroscope.

All macroinvertebrates were identified to the lowest practical level; usually genus. Chironomids and oligochaetes were mounted on glass slides in a clearing medium prior to identification. Following detailed identification, organisms were re-preserved in a solution of 70 to 80% ethanol in glass vials and labeled by station, replicate and contents. Data were tabulated in an Excel™ spreadsheet to facilitate analysis and interpretation. Taxonomic references used in the identification of organisms are provided in Appendix D.

2.4 DATA ANALYSIS

Each sample may contain hundreds of individuals and numerous different taxa, therefore, biotic indices that incorporate various community attributes are used to compare benthic communities both spatially (between stations) and temporally (within stations over time). The following community measures and indices were used to interpret the benthic macroinvertebrate data for this survey.

- Organism density;
- Taxa richness;
- EPT Index;
- BioMAP Water Quality Index;
- Hilsenhoff Biotic Index; and
- Relative abundance of selected taxonomic groups.

Each of these indices is described in more detail below.

Organism Density:

The total number of macroinvertebrates per m^2 (density) were determined for each sample. Mean values were also calculated for each station. Generally, low values can indicate toxic effects, often associated with pollutant inputs, and very high values can indicate nutrient enrichment.

Taxa Richness:

The number of distinct taxonomic groups, or taxa richness, is an indicator of community diversity. Mean and pooled taxa richness were calculated for each station. Typically, high diversity is an indicator of good quality habitat. In cases where immature individuals could not be identified to species, they were only counted as a unique taxon if there were no other organisms of the same genus in the same sample. This prevents the overestimation of taxa richness.

EPT Index:

The EPT index is a count of the number of taxa belonging to the taxonomic orders Ephemeroptera, Plecoptera and Trichoptera (mayflies, stoneflies, and caddisflies, respectively). These three groups typically include organisms that are sensitive to reductions in habitat quality. High EPT values are typically found in areas where water quality is good and benthic habitat is both complex and stable. Mean and pooled EPT taxa richness were calculated for each station.

BioMAP Water Quality Index:

The BioMAP rating system is a comprehensive index of the impairment of water quality due to human influences (Griffiths, 1998). The BioMAP index is based on the assumption that an upstream shift in the aquatic community can result from anthropogenic influences on a watercourse. The density-based index ($WQI_{(d)}$) expresses water quality as an abundance-weighted sensitivity value (index) which emphasizes sensitive and rare taxa. Each taxon is assigned a value from 0 to 4 based on its ecological sensitivities to anthropogenic impacts, with 0 representing the least sensitive and 4 representing the most sensitive values. The index is calculated using the following formula:

$$WQI_{(d)} = \frac{\left[\mathit{\Sigma}_{(1-n)}(e^{SVi} * In\,(x_i + 1))\right]}{\left[\Sigma_{(1-n)}\, In\,(x_i + 1)\right]}$$

Where:

SV_i = the sensitivity value of the i^{th} taxon
x_i = the density of the i^{th} taxon
n = the number of taxa in the sample
ln = the natural logarithm
e = 2.71828

Once calculated, index values are compared to established ratings based on watercourse size (width) to determine the level of impairment. BioMAP Water Quality Index (WQI_d) water quality impairment ratings are presented in Table 2. The rating system for Creeks and Streams were used for this study.

Table 2: BioMAP $WQI_{(d)}$ Rating System for Creeks, Streams and Rivers (Griffiths, 1998)

Watercourse Size	BioMAP Rating		
	Impaired	Inconclusive	Unimpaired
Creeks (Width < 4m)	< 14	14 - 16	> 16
Streams (Width 4 - 16 m)	< 10	10 - 12	> 12
Rivers (Width 16 - 64 m)	< 7	7 - 9	> 9
Large Rivers (Width 64 – 256 m)	< 5	5 - 7	> 7

The qualitative water quality index $WQI_{(q)}$ provides a measure of water quality based solely upon the presence of taxa at the site. It uses the same sensitivity values as the quantitative $WQI_{(d)}$ discussed above. The $WQI_{(q)}$ is the average sensitivity of the upper quartile (25%) of taxa within a station. The index is calculated using the following formula:

$$WQI_{(q)} = 1/k \left[\Sigma_{(1-n)}(SV_i)\right]$$

Where:

SV_i = the sensitivity value of the i^{th} ranked (highest to lowest) taxon
k = integer (n/4), k ≥4
n = the number of taxa at the station

Once calculated, index values are compared to established ratings based on watercourse size (width) to determine level of impairment. The BioMAP WQI_q water quality impairment ratings are presented in Table 3. The rating system for Creeks and Streams were used for this study.

Table 3: BioMAP $WQI_{(q)}$ Rating System for Creeks, Streams and Rivers (Griffiths, 1998)

Watercourse Size	BioMAP Rating		
	Impaired	Inconclusive	Unimpaired
Creeks (Width < 4m)	< 3.2	3.2 – 3.4	> 3.4
Streams (Width 4 - 16 m)	< 2.6	2.6 – 3.0	> 3.0
Rivers (Width 16 - 64 m)	< 2.0	2.0 – 2.4	> 2.4

Hilsenhoff Biotic Index:

The Hilsenhoff Biotic Index (HBI) is commonly used to determine the extent of organic nutrient enrichment (Hilsenhoff, 1987). Sensitivity values are assigned to each taxon based on their tolerance to organic nutrients ranging from 0 (intolerant) to 10 (very tolerant). The HBI is calculated using the following formula:

$$HBI = \frac{\left[\Sigma_{(1-n)}(SV_i * x_i)\right]}{n}$$

Where:

SV_i = the sensitivity value of the ith taxon
x_i = the density of the ith taxon
n = the number of taxa in the sample

For each station, the HBI is compared to the values listed in Table 4 to provide a rating of water quality with respect to organic enrichment.

Table 4: Hilsenhoff rating system (Hilsenhoff, 1987)

Biotic Index	Water Quality	Degree of Organic Enrichment
0.00-3.5	Excellent	No apparent enrichment
3.51-4.50	Very Good	Slight enrichment
4.51-5.50	Good	Some enrichment
5.51-6.50	Fair	Fairly significant enrichment
6.51-7.50	Fairly Poor	Significant enrichment
7.51-8.50	Poor	Very significant enrichment
8.51-10.00	Very Poor	Severe enrichment

Relative Abundance of Selected Taxonomic Groups:

The relative abundance (%) of major groups of macroinvertebrates was compared among stations, to determine differences in the overall structure of each of the benthic communities. Because some groups are more tolerant than others to disturbance and nutrient enrichment, dominance by a single species or group can be indicative of a stressed community. For example, chironomids and oligochaetes tend to be very tolerant of nutrient enrichment or polluted conditions. At highly contaminated sites, these two taxa are often the only remaining macroinvertebrates (Pinder, 1986).

3.0 RESULTS

3.1 SUPPORTING ENVIRONMENTAL DATA

Supporting field measurements and observations recorded during the 2014 and 2015 surveys are summarized in Table 5. A photographic record depicting station characteristics is provided in Appendix A and field data sheets are provided in Appendix B.

Table 5: Supporting Environmental Data by Benthic Station, Dodd Creek and Aukland Drain (November 2014 and April 2015)

Parameter	Station					
	Aukland Drain		Dodd/Aukland Confluence		Dodd Creek	
	1	2	3	4	5	6
Date	November 25, 2014	November 25, 2014	April 15, 2015	April 15, 2015	April 15, 2015	April 15, 2015
Time of Day	11:55	11:12	13:03	12:22	11:12	10:36
Dissolved Oxygen (mg/L)	14.7	15.0	13.3	13.1	12.9	12.7
Air Temperature (°C)	0	0	14	14	12	10
Water Temperature (°C)	4.6	4.5	10	9.4	8.2	7.9
pH	7.86	7.83	7.46	7.46	7.41	7.35
Conductivity (µS/cm)	516	493	829	831	834	837
Water Velocity (m/s)	0.98 – 1.01	0.81 – 1.07	0.58 – 0.63	1.22 – 1.28	0.36-0.42	0.38-0.46
Station Depth (m)	0.41 – 0.46	0.44 – 0.46	0.25	0.26	0.46-0.48	0.46-0.51
River Width (m)	2.5	2.5	6.0	7.0	7.0	7.0
Substrate Composition	Cobble, gravel and sand	Cobble, gravel and sand	Gravel, cobble, sand and silt	Gravel, cobble, sand and silt	Cobble, gravel, boulder and sand	Cobble, gravel, boulder and sand
Macrophytes and algae	Sparse *Cladophora*	Sparse *Cladophora*	Sparse *Cladophora*	Sparse *Cladophora*	Sparse *Cladophora*	Sparse *Cladophora*

Dissolved oxygen, pH, conductivity, depth, algae coverage and substrate composition were similar between paired stations (Table 5). Water velocity was noticeably slower at Station 3 than at Station 4. Differences in water velocity can result in differences in benthic community composition and may contribute to differences in the assessed endpoints between these stations.

3.2 DATA ANALYSIS

A summary of the calculated benthic community indices is provided in Table 6. The complete taxonomic list of benthic macroinvertebrates is provided in Appendix C.

Table 6: Summary of Calculated Benthic Community Indices, Dodd Creek and Aukland Drain (November 2014 and April 2015). Mean Values with Range in Parentheses.

Station	Aukland Drain		Dodd/Aukland Confluence		Dodd Creek	
	1	2	3	4	5	6
Index						
Abundance and Density						
Abundance	208 (85-332)	399 (209-589)	211 (127-295)	185 (160-210)	71 (48-94)	74 (72-77)
Density (# of organisms per m^2)	2242 (914-3570)	4290 (2247-6333)	2269 (1366-3172)	1989 (1720-2258)	763 (516-1011)	801 (774-828)
Taxa Richness						
Mean	24 (18-30)	27 (23-31)	31 (24-39)	29 (27-32)	16 (11-22)	21 (17-25)
Pooled	33	34	43	38	25	30
EPT Taxa Count						
Mean	5 (5-5)	5.5 (5-6)	7.5 (6-9)	5 (3-7)	5.5 (4-7)	4.5 (4-5)
Pooled	6	6	10	7	8	6
BioMAP Indices						
$WQI_{(d)}$	7.43 (7.05-7.81)	7.75 (7.68-7.82)	7.54 (7.30-7.79)	6.90 (6.66-7.14)	7.08 (6.71-7.46)	7.75 (6.07-9.42)
$WQI_{(d)}$ Interpretation	Impaired	Impaired	Impaired	Impaired	Impaired	Impaired
$WQI_{(q)}$	2.5	2.62	2.5	2.78	2.83	2.71
$WQI_{(q)}$ Interpretation	Impaired	Impaired	Impaired	Indeterminate	Indeterminate	Indeterminate
Hilsenhoff Biotic Index						
Mean	5.28 (5.2-5.36)	5.08 (4.88-5.29)	5.80 (5.77-5.84)	5.96 (5.40-6.52)	6.25 (6.12-6.39)	6.16 (6.06-6.26)

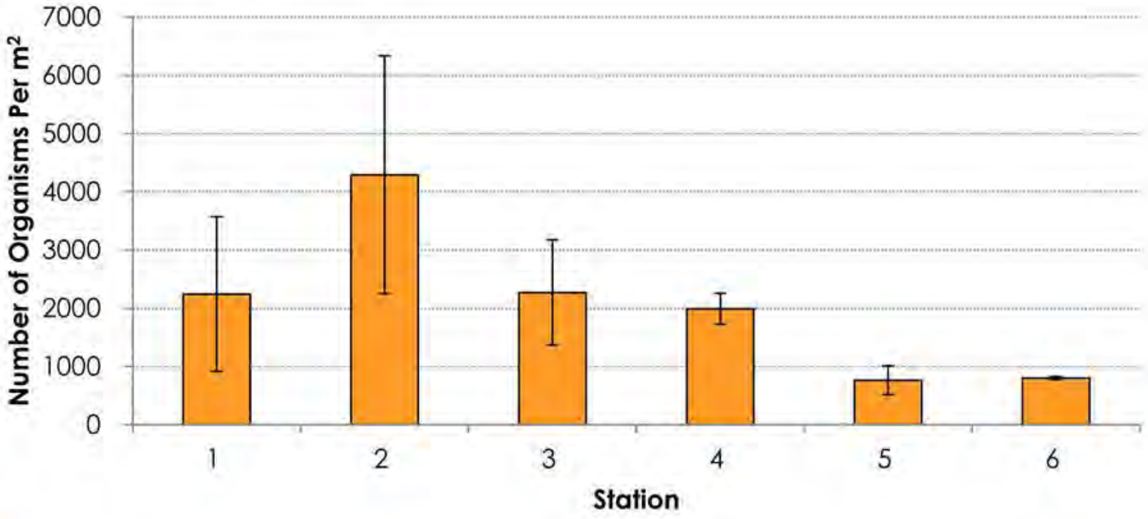
Table 6: Summary of Calculated Benthic Community Indices, Dodd Creek and Aukland Drain (November 2014 and April 2015). Mean Values with Range in Parentheses.

Station	Aukland Drain		Dodd/Aukland Confluence		Dodd Creek	
	1	2	3	4	5	6
HBI Interpretation	Good	Good	Fair	Fair	Fair	Fair
Mean Relative Abundance						
% Chironomids	8.3	10.7	52.6	16.3	50.1	48.4
% Oligochaetes	6.99	3.6	4.5	20.6	3.7	4.6
% EPT Organisms	26.7	28.7	18.1	6.6	35.1	22.9
% Coleoptera	45.4	49.2	12.1	44.1	7.9	14.6

Organism Density:

Organism density ranged between 763 (Station 5) and 4290 (Station 2) organisms per m² (Figure 2). Invertebrate densities were similar upstream and downstream on Dodd Creek at the proposed outfall and at its confluence with Aukland Drain. Density at the downstream station in Aukland Drain was twice that of the upstream station, however, variability was generally high in Aukland Drain benthic communities. Mean densities were similar to normal ranges for southern Ontario creeks and streams (Griffiths, 1999).

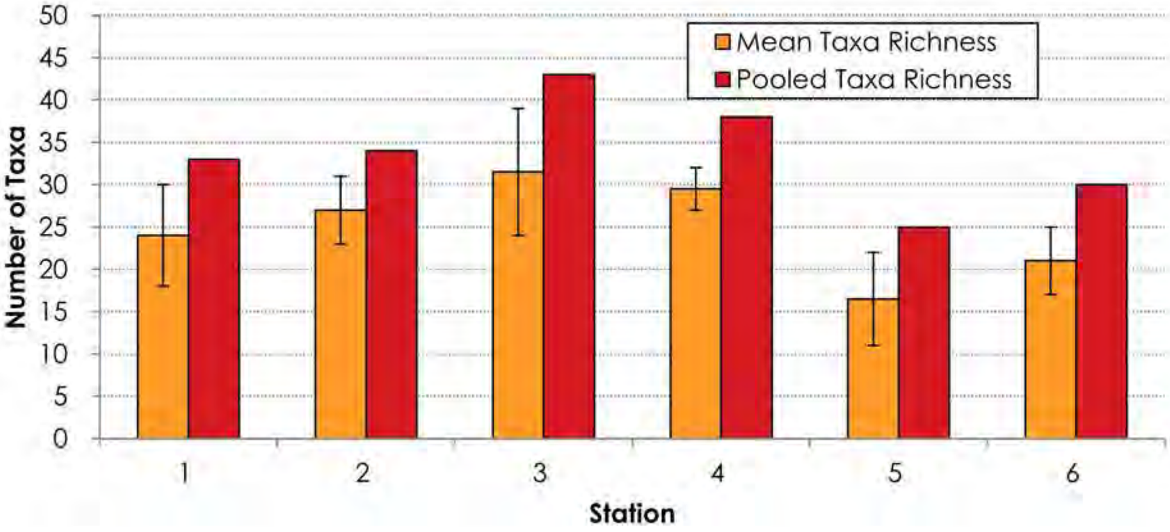
Figure 2: Mean Organism Density at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015). Error bars represent +/- 1 standard error about the mean.



Taxa Richness:

Mean taxa richness ranged between 16.5 taxa at Station 5 and 31.5 taxa at Station 3 (Figure 3). Pooled taxa richness ranged between 25 taxa at Station 5 and 43 taxa at Station 3. High taxa richness is typically indicative of excellent water quality and complex and stable habitats, while low taxa richness can be indicative of pollutant impacts or very poor or unstable habitat. For each pair of stations, benthic communities had similar diversity at upstream and downstream stations.

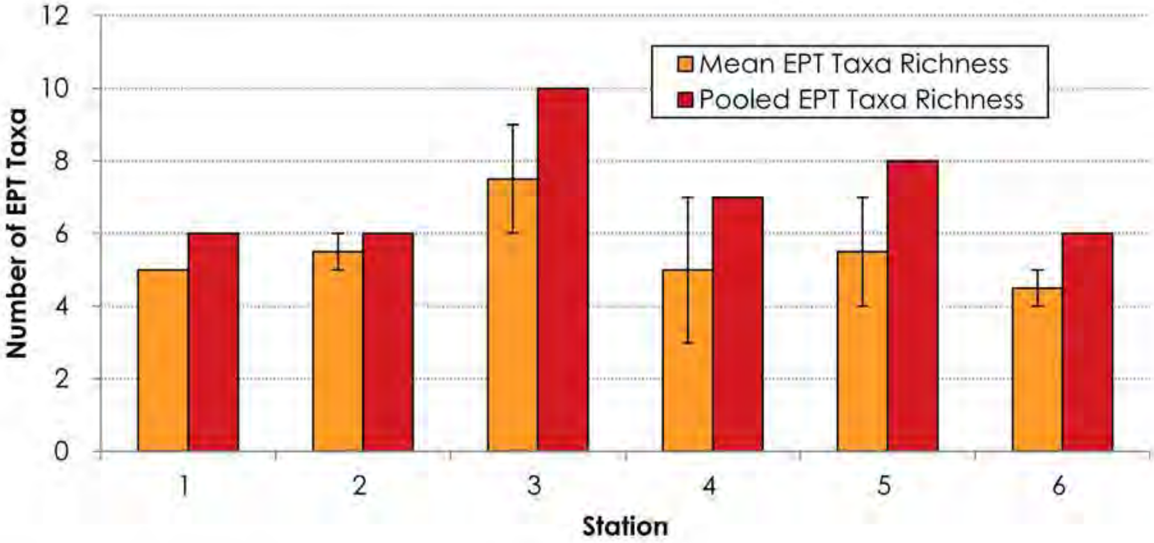
Figure 3: Mean and Pooled Taxa Richness at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015). Error bars represent +/- 1 standard error about the mean.



EPT Index:

Mean EPT taxa richness ranged between 4.5 taxa at Station 6 and 7.5 taxa at Station 3 (Figure 4). Pooled EPT taxa richness ranged between 6 taxa at Stations 1, 2 and 6 and 10 EPT taxa at Station 3. EPT taxa richness was similar between upstream and downstream stations at the proposed Aukland Drain outfall and at the proposed Dodd Creek outfall. EPT taxa richness was lower downstream than upstream of the confluence of Aukland Drain and Dodd Creek. This suggests that water quality or habitat quality may be lower downstream of the confluence.

Figure 4: Mean and Pooled EPT Taxa Richness at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015). Error bars represent +/- 1 standard error about the mean.



BioMAP Water Quality Index:

The BioMAP water quality indices from the Aukland Drain stations were compared to Creek ratings for watercourses less than 4 m wide (Tables 2 and 3). The BioMAP water quality indices from the Dodd Creek stations were compared to Stream ratings for watercourses between 4 m and 16 m wide (Tables 2 and 3). BioMAP $WQI_{(d)}$ endpoints were indicative of "impaired" water quality at all six stations (Figure 5).

With respect to the qualitative index (BioMAP $WQI_{(q)}$) Stations 1, 2 and 3 fell within the "impaired" range and Stations 4, 5 and 6 fell within the "inconclusive" range between impaired and unimpaired water quality (Figure 6).

Figure 5: **BioMAP $WQI_{(d)}$ at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015). Error bars represent +/- 1 standard error about the mean.**

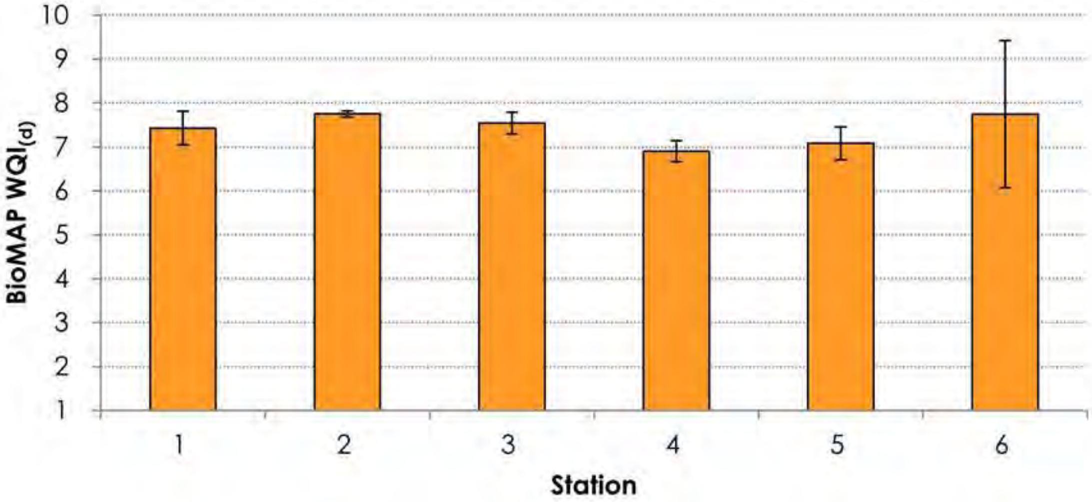
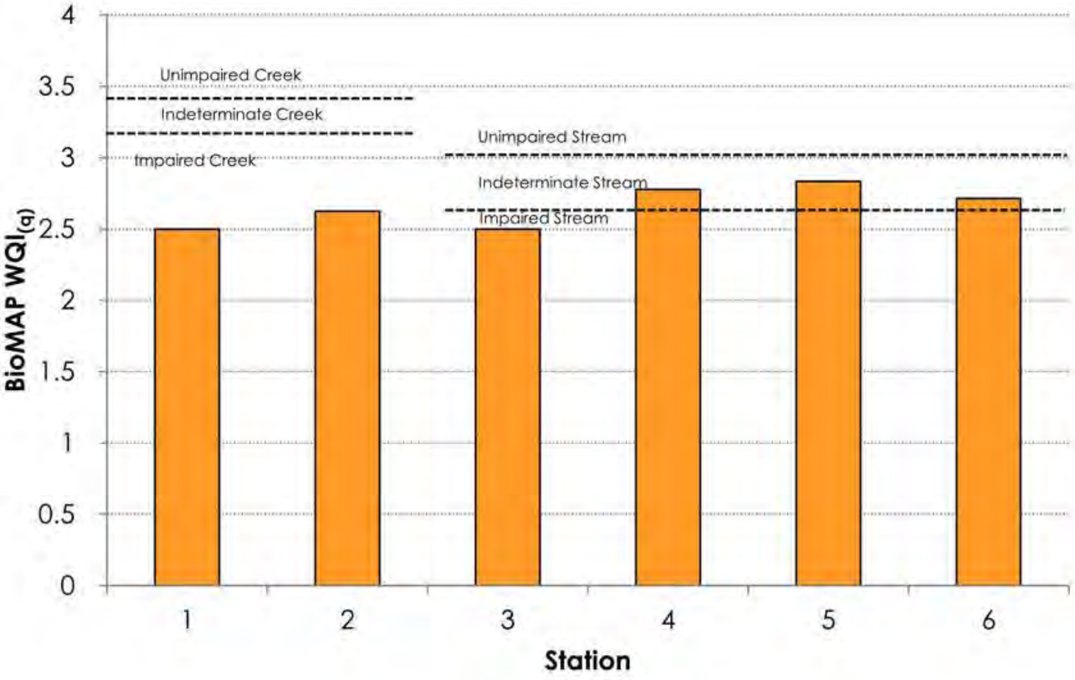


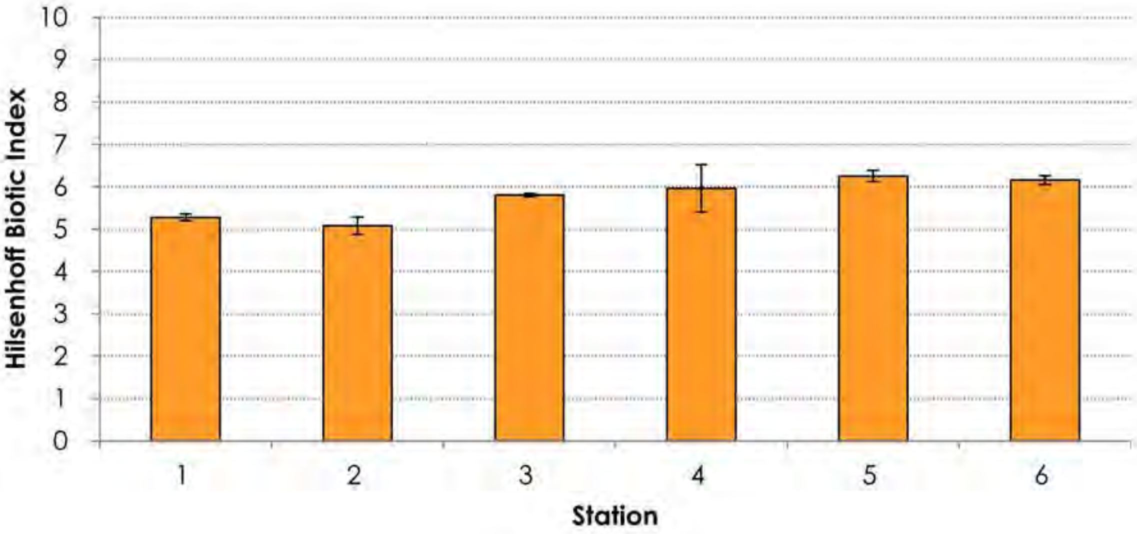
Figure 6: **BioMAP $WQI_{(q)}$ at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015).**



Hilsenhoff Biotic Index:

The Hilsenhoff Biotic Index indicated that water quality at the proposed Aukland Drain WWTP outfall option (Stations 1 and 2) was "Good" with "some enrichment" at both upstream and downstream stations. The HBI at the Stations 3 and 4 and at the proposed Dodd Creek WWTP outfall option (Stations 5 and 6) was "fair" with "fairly significant organic enrichment" at upstream and downstream stations. HBI values are illustrated in Figure 7. The HBI indicates that, for each pair of stations, benthic communities were similar in their tolerance to nutrients at upstream and downstream stations.

Figure 7: Hilsenhoff Biotic Index at Benthic Stations, Dodd Creek and Aukland Drain (November 2014 and April 2015). Error bars represent +/- 1 standard error about the mean.



Relative Abundance of Selected Taxonomic Groups:

The relative abundance of major taxonomic groups at all benthic invertebrate sampling stations are illustrated in Figure 8.

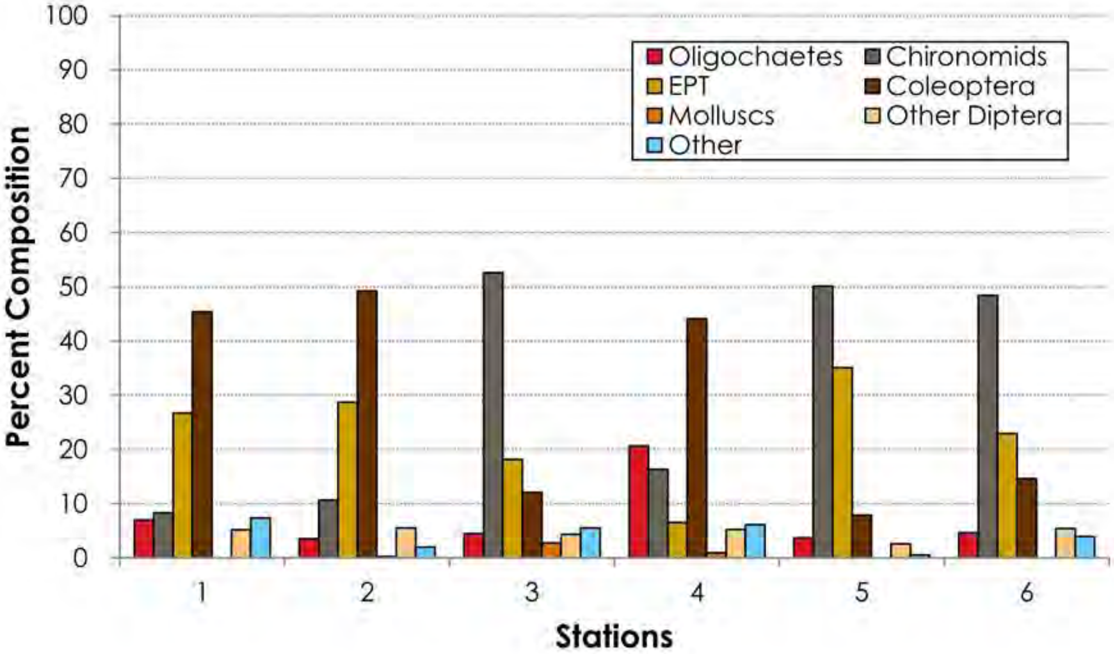
Aukland Drain Stations 1 and 2 had very similar community composition. They were dominated by Elmid beetles (Coleoptera) which accounted for over 45% of the organisms found. EPT organisms were the next most-dominant group, accounting for just over 26% of the organisms found. These organisms are typical of fast-flowing, well-oxygenated water over gravel and cobble substrates. They are also relatively sensitive to pollutants, so their presence here suggests good water quality.

Stations 5 and 6, at the proposed Dodd Creek WWTP outfall, had very similar community composition. The relative proportion of Chironomids was over 48% and the proportion of EPT organisms ranged between 22% and 35%.

Three stations in the survey were dominated by Chironomids, which are generally considered to be more tolerant of low water quality and relatively poor aquatic habitat conditions. Chironomids comprised between 48% and 52% of the benthic communities at stations 3, 5 and 6. This chironomid assemblage was comprised of more than eight distinct taxa with no single taxon representing more than 60% of the chironomid community. Although these communities were dominated by chironomids, this does not necessarily indicate environmental stress or poor water quality, as there was a relatively high diversity among the Chironomids present.

Oligochaetes accounted for approximately 20% of the benthic community at Station 4; downstream from the confluence of Aukland Drain and Dodd Creek. Oligochaetes are typically associated with nutrient-rich, fine sediments. This may indicate differences in substrate composition or habitat between Stations 3 and 4, since Oligochaetes were not as prevalent upstream.

Figure 8: Relative Abundance of Benthic Taxonomic Groups, Dodd Creek and Aukland Drain (November 2014 and April 2015)



4.0 SUMMARY AND CONCLUSIONS

This report documents the results of Stantec's benthic macroinvertebrate survey of Dodd Creek and Aukland Drain, for the proposed WWTP. The survey provides baseline benthic community information in the vicinity of the proposed WWTP outfalls to which subsequent during- and post-construction monitoring data can be compared.

The majority of the benthic community endpoints assessed indicated that there was no appreciable difference between upstream and downstream stations. The reduction in BioMAP scores from Station 3 to 4, coupled with the reduction in EPT taxa richness (Figure 4) and a shift in benthic community dominance from chironomids to worms and beetles (Table 6) may indicate that the Aukland Drain has some (non-toxic) impact on Dodd Creek benthic communities (i.e. water quality). This baseline benthic data indicates that upstream and downstream stations and benthic communities at the proposed Aukland Drain outfall and Dodd Creek outfall are similar enough to provide valid measures of potential impacts related to future effluent inputs.

This 2015 report represents the initial benthic monitoring and community analysis required by the MOECC as a supplement to the Southwold Assimilative Capacity Study. It is recommended that future baseline, during-construction and post-construction monitoring be conducted to assess potential impacts of WWTP effluent on aquatic organisms in the Aukland Drain and Dodd Creek receivers.

5.0 SIGN-OFF PAGE

This report has been prepared by Stantec for the sole benefit of the Township of Southwold and may not be used by any third party without the express written consent of our client. The data presented in this report are in accordance with Stantec's understanding of the project as it was presented at the time of reporting.

STANTEC CONSULTING LTD.

Prepared by Joe Keene
(signature)

Joe Keene, M.Sc., Senior Benthic Ecologist

Reviewed by Nancy Harttrup
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Nancy Harttrup, B.Sc., Senior Fisheries Biologist

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6.0 REFERENCES

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Pinder L.C.V. 1986. Biology of Freshwater Chironomidae, p. 1-23. In Mittler T.E., Radovsky F.J., Resh V.H. (eds.), Annual Review of Entomology 31. Annual Reviews, Inc., Palo Alto, CA.

APPENDIX A: PHOTOLOG

Photo 1: Gilbert Drain facing upstream (west), before its confluence with Aukland Drain.

Photo 2: Gilbert Drain facing downstream (northeast) at its confluence with Aukland Drain.

Photo 3: Station 1 on Aukland Drain facing downstream (south), toward its confluence with Gilbert Drain.

Photo 4: Watercress (*Nasturtium* sp.) from the vicinity of Station 1 on Aukland Drain, indicating probable groundwater inputs.

Photo 5: Station 2 on Aukland Drain facing upstream (west).

Photo 6: Station 2 on Aukland Drain facing downstream (east); overlooking benthic sampling riffle area.

Stantec

Client/Project Township of Southwold, Southwold Wastewater Treatment Facility	May 2015 165500796
Appendix A	Page 1 of 3
Title PHOTOGRAPHIC RECORD	

Photo 7: Station 3 benthic sampling area on Dodd Creek, facing upstream (north); upstream of its confluence with Aukland Drain.

Photo 8: Station 3 on Dodd Creek, facing downstream (south); upstream of its confluence with Aukland Drain.

Photo 9: Station 3 on Dodd Creek, facing downstream (southeast); showing its confluence with Aukland Drain.

Photo 10: Station 3 substrate depicting turbid water and cobble and gravel substrates.

Photo 11: Station 4 facing upstream (east), toward the Aukland Drain outlet.

Photo 12: Station 4 facing downstream (west), overlooking sampled riffle area.

Photo 13: Station 4 substrate, dominated by cobble and gravel.

Photo 14: Station 5 facing upstream (west), overlooking sampled riffle.

Photo 15: Station 5 facing downstream (east), overlooking sampled riffle.

Photo 16: Station 6 facing upstream (west), overlooking sampled riffle.

Photo 17: Station 6 facing downstream (east), overlooking sampled riffle.

APPENDIX B: BENTHIC FIELD SHEETS

Stantec

Benthic Sample Collection Form

Project Number: 165500796

Station ID: 1

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2014/11/25

Project Name: Talbotville Fernadale MSP

Descriptive Location: Aukland Drain upstream of confluence with Gilbert Drain

Water Body: Aukland Drain

UTM coordinates: 0481572 easting 4738127 northing zone: 17T datum: NAD 83

Sampling Method: Surber sampler

Number of Replicates: 2

Sampling Duration (minutes) (if applicable): —

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m): 2.5m

Water Clarity/Colour: brown/turbid.

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 4.57°C

Dissolved Oxygen: 14.70

Air Temperature: 0°C

pH: 7.86

Time: 11:55am

Conductivity: 516 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: One (1)

Depth (m): 0.41m

Water Velocity (m/s): 0.98 m/s

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/odour: 60% cobble 25% gravel 15% sand

1-1

Replicate 2 (all observations pertain to individual grabs)

blunt nosed minnow

Number of Jars: one (1)

Depth (m): 0.46 cm

Water Velocity (m/s): 1.01 m/s

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] Cladophora common abundant

Substrate description/Odour: 60% cobble 15% gravel 15% Sand

1-2

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

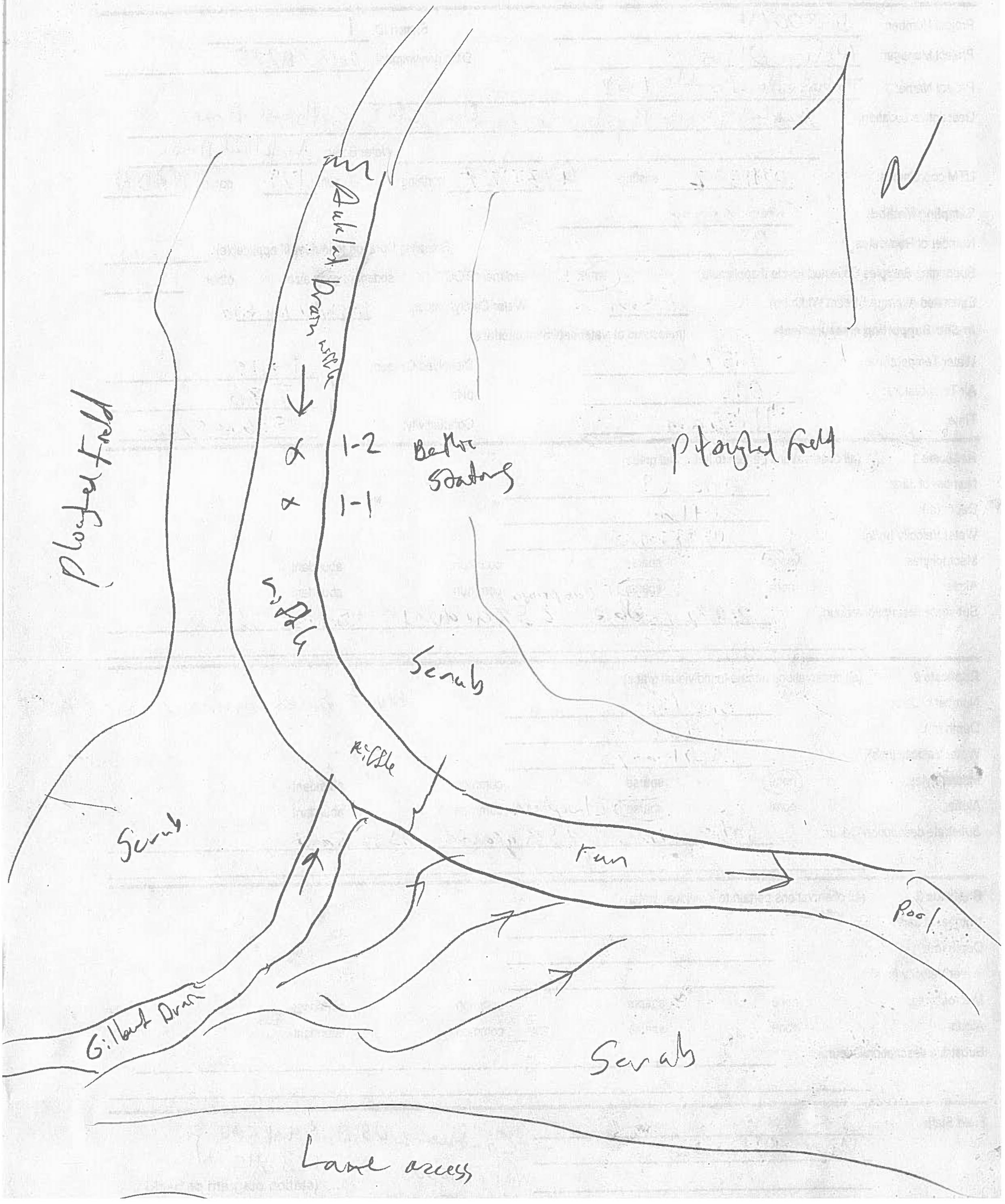
Substrate description/Odour:

Field Staff: Joe Rome
Kevin Vitone

Confluence US pt. 0481580 E
4738119 N

Watercress
present at confl

(station diagram on back)


N
Dublat Drain
riffle
1-2
1-1
Before Seating
Plowed Field
Plowed Field
riffle
Scrub
Riffle
Run
Pool
Scrub
Gilbert Drain
Scrubs
Lane access

Stantec

Benthic Sample Collection Form

Project Number: 165500796

Station ID: 2

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2014/11/25

Project Name: Talbotville & Ferndale MSP

Descriptive Location: Aukland Drain, Downstream of confluence with Gilbert Drain

Water Body: Aukland Drain

UTM coordinates: 0481716 easting 4738109 northing zone: 17T datum: NAD 83

Sampling Method: Surber Sampler

Number of Replicates: 2

Sampling Duration (minutes) (if applicable): –

Supporting Samples Collected (circle if applicable): water sediment TOC sediment grain size other:

Estimated Average Stream Width (m): 2.5m

Water Clarity/Colour: brown & turbid

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 4.51°C

Dissolved Oxygen: 15.01 mg/L

Air Temperature: 0°C

pH: 7.83

Time: 11:12 am

Conductivity: 493 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: One (1)

(high water condition)

Depth (m): 0.44 m

Water Velocity (m/s): 1.07 m/s

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] Cladophora common abundant

Substrate description/odour: 1-1 70% Cobble 20% gravel 10% Sand

Replicate 2 (all observations pertain to individual grabs)

Number of Jars: one (1)

Depth (m): 0.46 m

Water Velocity (m/s): 0.81 m/s

Macrophytes: none sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/Odour: 1-2 70% cobble 20% gravel 10% sand

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

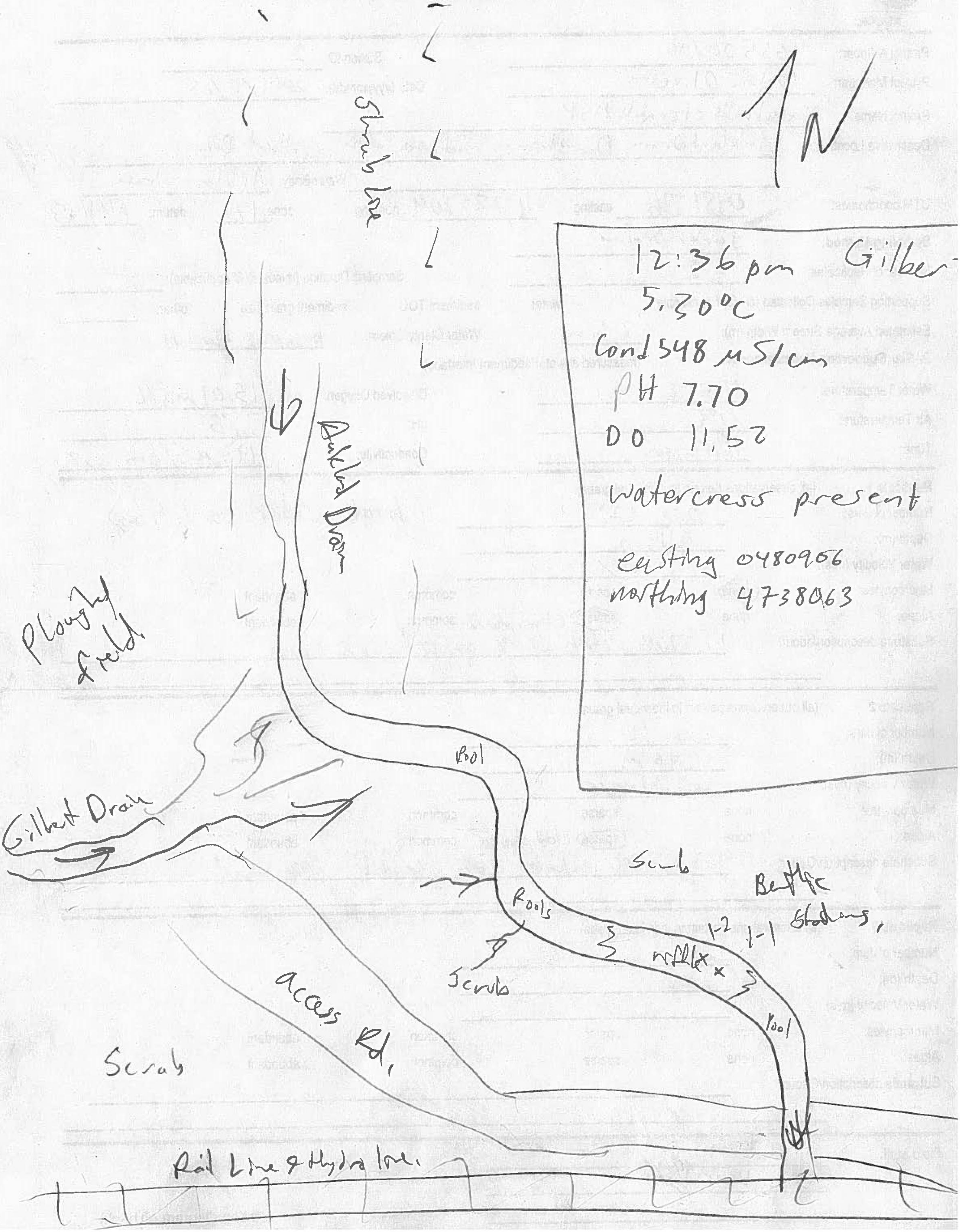
Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Joe Keen

Kevin Vidal

(station diagram on back)



12:36 pm Gilber

5.30°C

Cond 548 µS/cm

pH 7.70

DO 11.52

watercress present

easting 0480906

northing 4738063

Stantec

Benthic Sample Collection Form

Project Number: 165500796

Station ID: 3

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2014/11/25

Project Name: Talbotville & Ferndale MSP

Descriptive Location: Dodd creek, upstream of confluence with Auklnd Drain under old bridge

Water Body: Dodd Creek

UTM coordinates: 0482682 easting 4736751 northing zone: 17T datum: NAD 83

Sampling Method: Surber Sampler

Number of Replicates: 2

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m): 8 m

Water Clarity/Colour: turbid & brown

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 4.78°C

Dissolved Oxygen: 14.00 mg/L

Air Temperature: 0°C

pH: 8.00

Time: 17:23

Conductivity: 497 uS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars:

Depth (m): 1m+

Water Velocity (m/s):

unsafe water levels & velocities

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/odour:

Replicate 2 (all observations pertain to individual grabs)

Number of Jars:

Depth (m): 1m+

Water Velocity (m/s):

unsafe water levels & velocities

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Aukland Confluence CSI 13:36pm

Temp Air 0°C

Temp H_2O 4.26°C

Cond 522 uS/cm

pH 8.20

DO, 15.27 mg/L

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

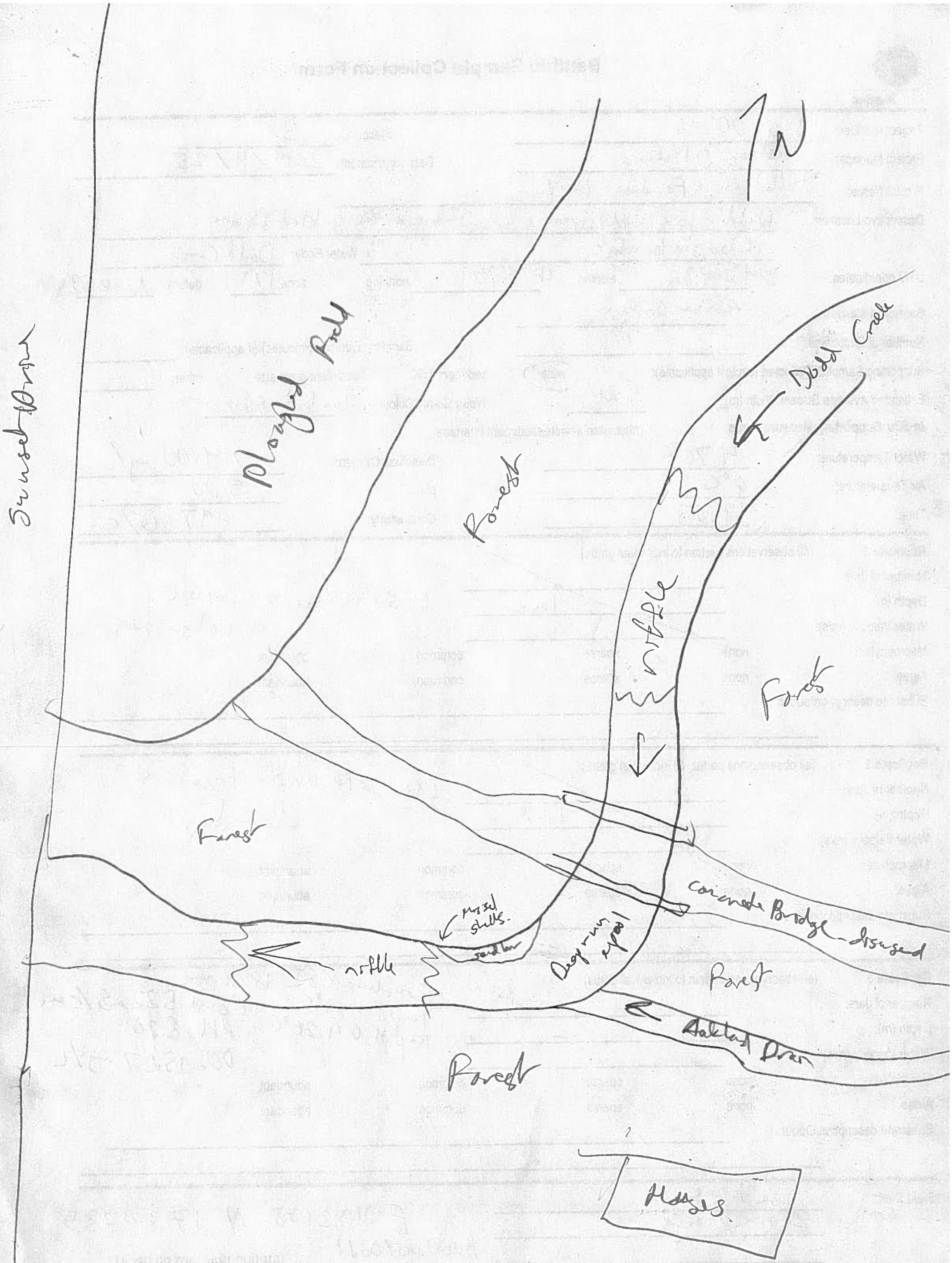
Field Staff: Joe Keane

Kevin Vitone

E 0482678 N 4736735

Auckland/Dodd

(station diagram on back)


N
Sunset Drive
Plowed field
Forest
Dodd Creek
riffle
Forest
Forest
Concrete Bridge - disused
mussel shells
sand bar
Deep run - pool
riffle
Forest
Aaklust Drain
Forest
Houses

Stantec

Benthic Sample Collection Form

Project Number: 165500796

Station ID: 4

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2014 / 11 / 25

Project Name: Talbotville & Ferndale MSP

Descriptive Location: Dodd Creek, Downstream of Confluence with Ashland Drain

Water Body: Dodd Creek

UTM coordinates: 482629 easting 4736705 northing zone: 17T datum: NAD83

Sampling Method: Surber Sampler

Number of Replicates: 2

Sampling Duration (minutes) (if applicable): —

Supporting Samples Collected (circle if applicable): water sediment TOC sediment grain size other:

Estimated Average Stream Width (m):

Water Clarity/Colour: turbid / brown

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 4.72 °C

Dissolved Oxygen: 14.31

Air Temperature: 0 °C

pH: 8.05

Time: 13:50

Conductivity: 506 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars:

Depth (m): 1m +

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/odour:

~~Unsafe~~ Unsafe water levels & velocities

Replicate 2 (all observations pertain to individual grabs)

Number of Jars:

Depth (m): 1m +

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Unsafe water levels & velocities.

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Shells of Pyganodon grandis & Lampsilis siliquoidea + 1 live P. grandis @ site.

Field Staff: Joe Keene
Kevin Vidone

(station diagram on back)

See stn 3
diagram

Stantec

Benthic Sample Collection Form

Project Number: 165500796

Station ID: 1

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2015/04/15

Project Name: Talbotville / Ferndale MSP

Descriptive Location: Ackland Drain Upstream of confluence with Gilbert Drain

Water Body: Ackland Drain

UTM coordinates: 0481572 easting 4738127 northing zone: 17T datum:

Sampling Method: YSI

Number of Replicates:

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m):

Water Clarity/Colour: clear

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 11.09°C

Dissolved Oxygen: 16.49 mg/L

Air Temperature: 15° C

pH: 7.87

Time: 14:00

Conductivity: 809 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/odour:

Replicate 2 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Joe Keene
Michelle Oxlade

(station diagram on back)

Stantec

Station Diagram:

(include North Arrow, Flow Direction and Road Names if applicable)

Field Staff: ______________________________

____

Notes By: ______________________________

Other Notes:

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Quality Control: This form is complete (__) & legible (__). QA/QC by: (signature) ______________

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Stantec

Benthic Sample Collection Form

photos

Project Number: 165500796

Station ID: 3

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2015/04/18

Project Name: Talbotville Ferndale MSP

Descriptive Location: Dodd creek, upstream of confluence with Auklet Drain

Water Body: Dodd Creek

UTM coordinates: 482664 easting 4736744 northing zone: 17T datum: NAD83

Sampling Method: Surber

Number of Replicates: 2

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m):

Water Clarity/Colour: brown/grey cloudy bottom visible

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 9.99°C

Dissolved Oxygen: 13.28 mg/L

Air Temperature: 14°C

pH: 7.46

Time: 13:03

Conductivity: 829 uS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 0.25

Water Velocity (m/s): 0.63

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/odour: 30% cobble 40% gravel 20% sand 10% silt

Replicate 2 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 0.25

Water Velocity (m/s): 0.58

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/Odour: 30 % cobble 40% gravel 20% sand 10% silt

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Joe Kerr

Michelle Oxlade

(station diagram on back)

water cress

Stantec

Station Diagram:

(include North Arrow, Flow Direction and Road Names if applicable)

Elk toe

White heelsplitter

Fat mucket - 1 live

Giant Floater

Field Staff: ______________________ **Notes By:** ______________________

____

Other Notes:

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Quality Control: This form is complete (__) & legible (__). QA/QC by: (signature) ______________

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Stantec

Benthic Sample Collection Form

photos

Project Number: 165500796

Station ID: 4

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2015/04/15

Project Name: Talbotville Ferndale MSP

Descriptive Location: Dodd creek, Downstream of confluence with Ackland Drain

Water Body: Dodd creek

UTM coordinates: 482634 ~~473~~ easting 4736701 northing zone: 17T datum: NAD 83

Sampling Method: Surber

Number of Replicates: 2

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m):

Water Clarity/Colour: brown grey / cloudy bottom visible

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 9.39

Air Temperature: ~~12~~ 14°C

Time: 12:22

Dissolved Oxygen: 13.10 mg/L

pH: 7.46

Conductivity: 831 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): .26

Water Velocity (m/s): 1.28

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] common abundant cladophora

Substrate description/odour: 20% cobble 50% gravel 20% sand 10% silt

Replicate 2 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): .26

Water Velocity (m/s): 1.22

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] common abundant cladophora

Substrate description/Odour: 20% cobble 50% gravel 20% sand 10% silt

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Joe Kime

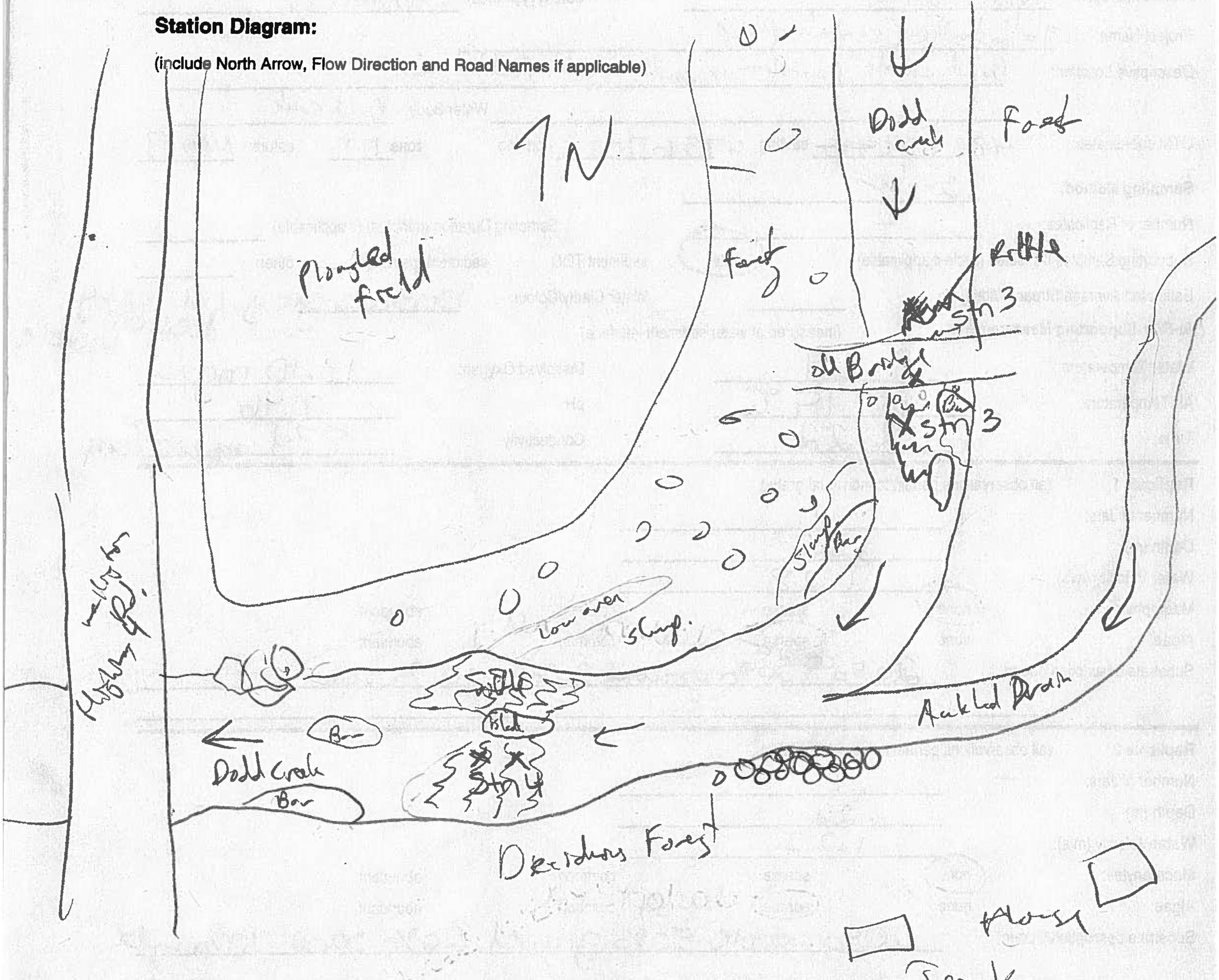
Michele Oxlade

(station diagram on back)

Goose scat
water cress

Station Diagram:

(include North Arrow, Flow Direction and Road Names if applicable)



Field Staff: ______________________

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Notes By: Joe Keene

Other Notes:

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Quality Control: This form is complete (__) & legible (__). QA/QC by: (signature) ______________

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Stantec

Benthic Sample Collection Form

Photos

Project Number: 165500796

Station ID: 5

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2015/04/15

Project Name: Talbotville Ferndale MSP

Descriptive Location: Dodd Creek - Upstream site - us of proposed WWTF ✓ACS station 3

Water Body: Dodd creek

UTM coordinates: 480558 easting 4737496 northing zone: 17T datum: NAD 83

Sampling Method: Surber

Number of Replicates: 2

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m): 7.0

Water Clarity/Colour:

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 8.21

Dissolved Oxygen: 12.90 mg/L

Air Temperature: 12°C

pH: 7.41

Time: 11:12 am

Conductivity: 834 uS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 46cm

Water Velocity (m/s): ~~0.60~~ 0.42

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/odour: Cobble 50%, gravel 30%, Boulder 10%, Sand 10%

Replicate 2 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 48 cm

Water Velocity (m/s): ~~0.51~~ 0.36

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] cladophora common abundant

Substrate description/Odour: Cobble 50%, gravel 30%, Boulder 10%, sand 10%

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Joe Kere

Rochelle Oxlade

Carlin Gorre

(station diagram on back)

Stantec

Wood Frog

~~Snapping turtle.~~

Deer tracks + scat

Station Diagram:

(include North Arrow, Flow Direction and Road Names if applicable)

Field Staff: ______________________________

____

Notes By: ____________________

Other Notes:

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Quality Control: This form is complete (__) & legible (__). QA/QC by: (signature) ____________

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Stantec

Benthic Sample Collection Form

Photos

Project Number: 165500796

Station ID: 6

Project Manager: Nelson Oliveira

Date (yyyymmdd): 2015 /04/25

Project Name: Talbotville Ferndale MSP

Descriptive Location: Dodd creek DS of proposed WWTF @ Upstream site
ACS station 3

Water Body:

UTM coordinates: 480640 easting 4737516 northing zone: 17T datum: NAD83

Sampling Method: Surber

Number of Replicates: 2

Sampling Duration (minutes) (if applicable):

Supporting Samples Collected (circle if applicable): [✓ water] sediment TOC sediment grain size other:

Estimated Average Stream Width (m): 7m

Water Clarity/Colour: Brown - cloudy

***In-Situ* Supporting Measurements** (measured at water/sediment interface)

Water Temperature: 7.87°C

Dissolved Oxygen: 12.72 mg/L

Air Temperature: 10°C

pH: 7.35

Time: 10:36am

Conductivity: 837 µS/cm

Replicate 1 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 0.46

Water Velocity (m/s):

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] Cladophora common abundant

Substrate description/odour: Cobble 50%, gravel 30%, Boulder 10% Sand 10%

Replicate 2 (all observations pertain to individual grabs)

Number of Jars: 1

Depth (m): 0.51

Water Velocity (m/s):

Macrophytes: [✓ none] sparse common abundant

Algae: none [✓ sparse] Cladophora common abundant

Substrate description/Odour: Cobble 50%, gravel 30% Boulder 10% Sand 10%

Replicate 3 (all observations pertain to individual grabs)

Number of Jars:

Depth (m):

Water Velocity (m/s):

Macrophytes: none sparse common abundant

Algae: none sparse common abundant

Substrate description/Odour:

Field Staff: Doc Kerr
Cam Gowrie
Michelle Oakdell

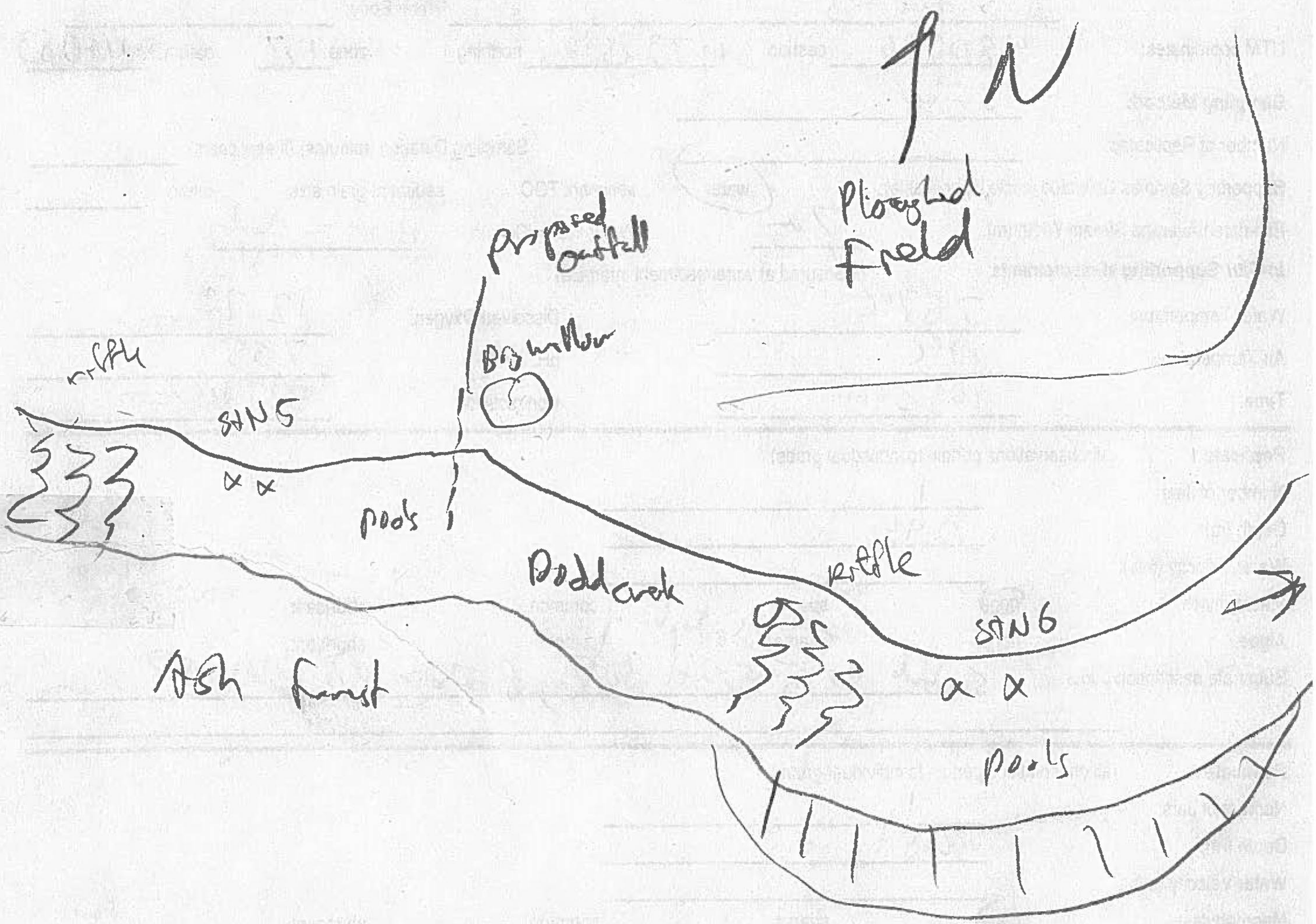
(station diagram on back)

snapping turtle

Stantec

Station Diagram:

(include North Arrow, Flow Direction and Road Names if applicable)



Field Staff: Joe Kerr Michelle O'Leary Len Coovre **Notes By:** Joe Kerr

Other Notes:
Snapping turtle on site @STN6

Quality Control: This form is complete (__) & legible (__). QA/QC by: (signature) ____________
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APPENDIX C: TAXONOMIC LIST OF BENTHIC ORGANISMS

APPENDIX C - BENTHIC MACROINVERTEBRATES COLLECTED FROM AUKLAND DRAIN AND DODD CREEK, 2014 and 2015.(densities expressed per m^2)

Station	Hilsenhoff Tolerance Value	BioMAP Sensitivity Value	1		2		3		4		5		6	
Replicate			1	2	1	2	1	2	1	2	1	2	1	2
ROUNDWORMS														
P. Nematoda	5	*	22	108	22	140	97	54	65	43	-	-	11	43
FLATWORMS														
P. Platyhelminthes														
Cl. Turbellaria														
O. Tricladida	6	3	-	-	-	-	-	-	-	-	-	-	-	-
Dugesia tigrina	6	1	-	-	-	-	-	22	32	108	-	-	-	-
ANNELIDS														
P. Annelida														
WORMS														
Cl. Oligochaeta														
F. Enchytraeidae	10	1	-	-	-	11	-	11	22	-	-	-	-	11
F. Haplotaxidae														
Haplotaxis gordioides	5	*	-	-	-	-	-	-	22	-	-	-	-	-
F. Naididae														
Nais	8	1	-	-	-	-	11	22	65	-	-	22	11	11
F. Tubificidae														
Branchiura sowerbyi	6	0	-	-	-	-	-	-	-	-	-	-	11	11
Limnodrilus hoffmeisteri	10	0	54	11	22	118	-	11	226	43	-	32	-	-
Potamothrix bavaricus	8	2	-	-	-	-	-	-	-	11	-	-	-	11
immatures with hair chaetae	10	0	11	-	-	-	-	11	-	11	-	-	-	-
immatures without hair chaetae	10	0	161	54	32	161	75	32	194	65	-	22	-	11
F. Lumbricidae														
Eiseniella tetraedra	6	0	22	-	-	11	-	-	-	-	-	-	-	-
F. Sparganophilidae														
Sparganophilus	*	0	-	-	-	-	-	-	11	97	-	-	-	-
LEECHES														
Cl. Hirudinea														
F. Erpobdellidae														
Erpobdella punctata	10	1	-	-	-	-	-	22	-	-	-	-	-	-
ARTHROPODS														
P. Arthropoda														
MITES														
Cl. Arachnida														
O. Acarina	6	*	32	11	-	32	-	32	-	-	-	11	-	-
WATER SCUDS														
O. Amphipoda														
F. Hyalellidae														
Hyalella	8	2	11	-	-	22	-	-	-	-	-	-	-	-
CRAYFISH														
O. Decapoda														
F. Cambaridae														
Orconectes propinquus	6	2	-	-	-	-	-	-	-	-	-	-	-	11

APPENDIX C - BENTHIC MACROINVERTEBRATES COLLECTED FROM AUKLAND DRAIN AND DODD CREEK, 2014 and 2015.(densities expressed per m^2)

Station	Hilsenhoff Tolerance Value	BioMAP Sensitivity Value	1		2		3		4		5		6	
Replicate			1	2	1	2	1	2	1	2	1	2	1	2
INSECTS														
Cl. Insecta														
BEETLES														
O. Coleoptera														
F. Curculionidae	5	*	-	-	-	-	11	-	-	-	-	-	-	11
F. Elmidae														
Ancyronyx variegata	5	2	-	-	-	-	-	11	-	-	-	-	-	-
Dubiraphia minima	6	1	-	-	-	-	-	-	-	-	-	-	-	11
Dubiraphia quadrinotata	5	1	-	-	11	11	-	-	-	-	-	-	-	-
Dubiraphia vittata	6	2	-	-	-	-	-	11	-	-	-	-	-	-
Dubiraphia larvae	6	*	11	-	-	**32**	-	**11**	11	32	-	-	-	**11**
Optioservus fastiditus	4	2	-	-	22	65	-	-	-	-	-	-	-	-
Optioservus larvae	4	2	204	65	**140**	**495**	-	11	75	54	-	-	-	32
Stenelmis crenata	5	2	118	22	161	215	-	22	11	11	-	-	-	11
Stenelmis larvae	5	2	**1312**	**323**	**989**	**1688**	43	**430**	**312**	**1312**	32	43	75	**75**
F. Psephenidae														
Ectopria	5	3	-	-	-	-	-	-	11	-	-	-	-	-
Psephenus	4	3	-	-	-	-	43	22	-	32	11	32	11	-
F. Staphylinidae	*	*	-	-	-	-	11	-	-	-	-	-	-	-
MAYFLIES														
O. Ephemeroptera														
F. Baetidae														
Baetis intercalaris	5	2	-	-	-	-	-	11	-	-	-	11	-	-
F. Caenidae														
Caenis	6	1	269	11	22	161	97	323	65	22	32	43	-	43
F. Heptageniidae														
Stenacron interpunctatum	7	2	-	-	-	-	-	-	11	-	151	97	161	54
Stenonema femoratum	7	1	-	-	-	-	11	32	-	-	65	22	22	32
STONEFLIES														
O. Plecoptera														
F. Capniidae														
Allocapnia rickeri	3	3	290	86	269	430	-	-	43	11	-	11	-	-
F. Perlidae														
Acroneuria	0	2	-	-	-	-	-	11	-	-	-	-	-	-
F. Perlodidae														
Isoperla bilineata	2	2	-	-	-	-	-	-	-	-	-	11	-	-
CADDISFLIES														
O. Trichoptera														
F. Helicopsychidae														
Helicopsyche	3	2	-	-	-	-	-	-	11	-	-	-	-	-
F. Hydropsychidae														
Cheumatopsyche	5	*	548	75	215	1075	75	161	32	11	-	-	11	22
Hydropsyche betteni	6	2	22	11	22	323	11	11	-	-	-	-	-	11
Hydropsyche bronta	6	3	-	-	-	-	-	32	22	-	-	-	11	-
Hydropsyche morosa	6	2	-	-	-	-	32	-	-	-	-	-	-	-

APPENDIX C - BENTHIC MACROINVERTEBRATES COLLECTED FROM AUKLAND DRAIN AND DODD CREEK, 2014 and 2015.(densities expressed per m^2)

Station	Hilsenhoff Tolerance Value	BioMAP Sensitivity Value	1		2		3		4		5		6	
Replicate			1	2	1	2	1	2	1	2	1	2	1	2
Hydropsyche slossonae	4	3	-	11	-	-	-	-	-	-	-	-	-	-
F. Hydroptilidae														
Hydroptila	6	2	-	-	-	-	11	11	11	-	11	-	-	-
F. Leptoceridae														
Oecetis	5	2	-	-	-	11	-	11	-	-	-	-	-	-
F. Limnephilidae														
Limnephilus	3	1	22	-	-	-	-	-	-	-	-	-	-	-
F. Polycentropodidae														
Polycentropus	6	*	-	-	-	-	-	-	-	-	-	11	-	-
F. Rhyacophilidae														
Rhyacophila lobifera	1	3	-	-	32	65	-	-	-	-	-	-	-	-
TRUE FLIES														
O. Diptera														
BITING-MIDGE														
F. Ceratopogonidae														
Mallochohelea	6	0	54	11	32	118	-	11	43	-	-	-	11	11
MIDGES														
F. Chironomidae														
chironomid pupae	*	*	-	-	-	**22**	**215**	**344**	**43**	-	**43**	**43**	**32**	**118**
S.F. Chironominae														
Cladotanytarsus	5	2	-	-	-	-	54	11	86	32	-	11	32	-
Cryptochironomus	8	1	11	-	-	11	-	-	-	-	-	-	-	-
Dicrotendipes	8	0	11	-	-	-	-	-	-	-	-	11	-	11
Micropsectra	7	3	-	-	-	183	-	-	-	-	-	11	-	-
Microtendipes	5	2	-	-	-	-	86	151	32	54	-	-	-	-
Paratanytarsus	6	1	65	22	54	398	43	11	-	-	11	75	11	11
Phaenopsectra	7	1	11	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	4	3	-	-	-	-	-	11	-	-	-	-	-	-
Polypedilum scalaenum	6	1	-	-	-	22	11	11	86	32	-	11	-	11
Polypedilum	6	*	11	-	-	-	-	-	-	-	-	-	-	-
Rheotanytarsus	6	3	-	-	-	-	-	-	-	-	-	11	-	-
Tanytarsus	6	2	43	-	-	11	-	-	-	-	-	-	-	-
S.F. Orthocladiinae														
Cricotopus	7	2	22	22	22	204	226	699	43	65	108	290	247	204
Diplocladius	8	3	11	-	-	-	-	-	-	-	-	-	-	-
Eukiefferiella	4	3	-	-	-	-	65	97	22	11	-	-	65	-
Hydrobaenus	8	1	-	-	11	32	-	-	11	-	-	-	-	-
Parakiefferiella	4	2	22	32	22	108	75	151	22	32	32	172	11	11
Parametriocnemus	5	3	-	-	-	11	-	54	-	-	-	-	-	-
S.F. Tanypodinae														
Natarsia	8	3	75	-	-	-	-	-	11	-	-	-	-	11
Thienemannimyia complex	6	2	22	-	11	22	-	-	11	32	-	-	-	-
F. Empididae														
Chelifera	6	2	11	-	11	22	-	-	-	-	-	-	-	-
Hemerodromia	6	2	22	11	32	65	11	-	-	22	-	-	-	11
F. Simuliidae														

APPENDIX C - BENTHIC MACROINVERTEBRATES COLLECTED FROM AUKLAND DRAIN AND DODD CREEK, 2014 and 2015.(densities expressed per m^2)

Station	Hilsenhoff Tolerance Value	BioMAP Sensitivity Value	1		2		3		4		5		6	
Replicate			1	2	1	2	1	2	1	2	1	2	1	2
Simulium	5	2	-	11	11	-	11	194	11	54	11	-	11	-
F. Tabanidae														
Chrysops	5	2	75	-	65	22	-	11	11	11	11	-	-	-
F. Tipulidae														
Antocha	3	3	-	-	-	22	-	11	43	11	-	11	32	11
Tipula	6	*	-	22	11	-	-	-	-	-	-	-	-	-
MOLLUSCS														
P. Mollusca														
SNAILS														
Cl. Gastropoda														
F. Physidae														
Physella	8	0	-	-	11	-	-	11	-	-	-	-	-	-
CLAMS														
Cl. Bivalvia														
F. Sphaeriidae														
Pisidium (Cyclocalyx)	6	*	-	-	-	-	11	22	-	22	-	-	-	-
Sphaerium (Musculium)	6	1	-	-	-	-	32	43	-	22	-	-	-	-
TOTAL NUMBER OF ORGANISMS			3570	914	2247	6333	1366	3172	1720	2258	516	1011	774	828
TOTAL NUMBER OF TAXA [a]			30	18	23	31	24	39	32	27	11	22	17	25

[a] Bold entries excluded from taxa count

APPENDIX D: TAXONOMIC BIBLIOGRAPHY

Appendix D Taxonomic Bibliography

Taxonomic References and Identification Levels for Benthic Macroinvertebrate Groups

Group	Taxonomic Level	Taxonomic References
Coelenterata	Genus	Smith, 2001
Turbellaria	Class/Species	Kenk, 1972; Kenk, 1976; Kenk, 1989; Smith, 2001; Thorp and Covich, 2001
Nematoda	Phylum	Smith, 2001; Thorp and Covich, 2001
Nemertea	Genus	Smith, 2001; Thorp and Covich, 2001
Tardigrada	Class	Smith, 2001; Thorp and Covich, 2001
Oligochaeta	Species	Brinkhurst, 1986; Brinkhurst and Cook, 1974; Kathman and Brinkhurst, 1999; Thorp and Covich, 2001
Polychaeta	Species	Smith, 2001
Hirudinea	Species	Davies, 1971; Klemm, 1972; Klemm, 1982; Klemm, 1991; Sawyer, 1974; Thorp and Covich, 2001
Acarina	Order	Cook, 1974; Cook, 1976; Thorp and Covich, 2001
Ostracoda	Class	Smith, 2001; Thorp and Covich, 2001
Harpacticoida	Order	Smith, 2001
Amphipoda	Genus/Species	Bousfield, 1958; Holsinger, 1976
Isopoda	Genus	Smith, 2001; Williams, 1976
Decapoda	Species	Crocker and Barr, 1968; Fetzner, 2004; Hobbs and Hall, Jr., 1974; Thorp and Covich, 2001
Mysidacea	Species	Smith, 2001
Collembola	Order/Genus/Species	Thorp and Covich, 2001; Waltz and McCafferty, 1979
Ephemeroptera	Genus/Species	Allen, 1978; Allen and Edmunds, Jr., 1961; Allen and Edmunds, Jr., 1962; Allen and Edmunds, Jr., 1963; Allen and Edmunds, Jr., 1965; Allen and Edmunds, Jr., 1976; Beaty, 2001; Bright, 2013; Burian, 2002; Burks, 1953; Edmunds, 1959; Edmunds and Allen, 1957; Edmunds and Allen, 1964; Edmunds *et al*., 1963; Edmunds *et al*., 1976; Jacobus and McCafferty, 2008; McCafferty, 1975; McCafferty, 2000; McCafferty et al., 2008; McCafferty and Randolph, 1998; Merritt and Cummins, 1996; Pescador and Berner, 1981; Pescador and Richard, 2004; Pfeiffer *et al*., 2008

Taxonomic References and Identification Levels for Benthic Macroinvertebrate Groups

Group	Taxonomic Level	Taxonomic References
Baetidae	Genus/Species	Bergman and Hilsenhoff, 1978; BugLab, 2003; Burian and Myers, 2011; Ide, 1937; Lehmkulh, 2009; Lowen and Flannagan, 1991; Lowen and Flannagan, 1992; Lugo-Ortiz and McCafferty, 1995; Lugo-Ortiz and McCafferty, 1998; Lugo-Ortiz *et al*., 1999; McCafferty and Jacobus, 2001; McCafferty and Waltz, 1990; McCafferty et al., 2005; Morihara and McCafferty, 1979; Pfeiffer *et al*., 2008; Waltz, 1994
Ephemeridae	Genus/Species	McCafferty, 1974
Heptageniidae	Genus/Species	Bednarik and McCafferty, 1979; Bright, 2013; Burian *et al*., 2008; Tomka and Zurwerra, 1985; Webb and McCafferty, 2008
Odonata	Genus/Species	Bright, 2013; Merritt and Cummins, 1996; Walker, 1953; Walker, 1958; Walker and Corbet, 1975
Plecoptera	Genus/Species	Bright, 2013; Frison, 1935; Fullington and Stewart, 1980; Harper and Hynes, 1971**a**; Harper and Hynes, 1971**b**; Harper and Hynes, 1971**c**; Harper and Hynes, 1971**d**; Hitchcock, 1974; Merritt and Cummins, 1996; Peterson and van Eeckhaute, 1990; Pfeiffer *et al*., 2008; Ricker and Ross, 1975; Stewart and Oswood, 2006; Stewart and Stark, 2002
Hemiptera	Species	Bright, 2013; Brooks and Kelton, 1967; Cheng and Fernando, 1970; Epler, 2006; Hilsenhoff, 1981; Tinerella and Gundersen, 2005
Homoptera	Order	Merritt and Cummins, 1996
Trichoptera	Genus/Species	Flint, Jr., 1984; Floyd, 1995; Merritt and Cummins, 1996; Parker and Wiggins, 1987; Ross, 1944; Schefler and Wiggins, 1986; Schmude and Hilsenhoff, 1986; Schuster and Etnier, 1978; Wiggins, 1996; Wold, 1974
Coleoptera	Genus/Species	Archangelsky, 1997; Brown, 1976; Epler, 2006; Hilsenhoff and Schmude, 1992; Larson *et al*., 2000; Merritt and Cummins, 1996
Megaloptera	Genus	Merritt and Cummins, 1996
Lepidoptera	Family/Genus	Merritt and Cummins, 1996
Diptera	Genus	Adler *et al*., 2004; Carpenter and LaCasse, 1974; Johannsen, 1970; Kiefer *et al*., 1972; Löffler, 1986; McAlpine *et al*., 1981; McAlpine *et al*., 1987; McAlpine and Wood, 1989; Merritt and Cummins, 1996; Pfeiffer *et al*., 2008; Sæther, 1970; Teskey, 1990; Wood *et al*., 1979

Taxonomic References and Identification Levels for Benthic Macroinvertebrate Groups

Group	Taxonomic Level	Taxonomic References
Chironomidae	Genus/Species	Boesel, 1985; Bolton, 2007; Ekrem, 2007; Epler, 2001; Jackson, 1977; Johannsen, 1970; Maschwitz and Cook, 2000; Oliver and Dillon, 1990; Oliver and Roussel, 1983; Roback, 1976; Simpson and Bode, 1980; Simpson *et al*., 1983; Wiederholm, 1983; Wiederholm, 1986; Wiederholm, 1989
Gastropoda	Genus/Species	Burch, 1982; Clarke, 1981; Jokinen, 1992; Prescott and Curteanu, 2004; Thompson, 2004; Thorp and Covich, 2001; Wethington, 2004
Bivalvia	Genus/Species	Domm *et al*., 1993; Clarke, 1981; Fuller, 1974; Mackie *et al*., 1980; Metcalfe-Smith *et al*., 2005
Dreissenidae	Species	Domm *et al*., 1993
Sphaeridae	Species	Clarke, 1981 Mackie *et al*., 1980
Unionidae	Species	Clarke, 1981; Metcalfe-Smith *et al*., 2005

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