- "Former CFB Rockcliffe Stormwater Management Ponds, Ottawa, Ontario" dated June 2014 (DST File No. OE-OT-017184)
- "Community Design Plan Geotechnical Investigation Former CFB Rockcliffe Development, Ottawa, Ontario" dated June 2014 (DST File No. OE-OT-015358)
- "Hydrogeological Report Stormwater Management Support Study" dated June 2014 (DST File No. OE-OT-017184)
- "Preliminary Geotechnical Investigation Study Report Infiltration Ponds" dated November 2013 (DST File No. OE-OT-017184)

Much of the site geology information is extracted from the "Former CFB Rockcliffe Redevelopment Stormwater Management Existing Conditions and LID Pilot Project Scoping" report prepared by Aquafor Beech, May 2015. This section also reviews some of the geotechnical elements and recommendations respecting specific site development parameters.

The geotechnical investigations were completed in support of a concept plan in which both proposed SWM facilities were located off-site. As noted in **Section 1.5**, the plan has since been refined as part of the on-going planning process (the latest preferred plan is presented on **Figure 1.3**). Three major system dry ponds are proposed on-site to attenuate major flow. Ultimately, these ponds may also function as infiltration ponds to encourage localized infiltration of runoff. The geotechnical investigations were completed to support this development concept.

2.2.2 Surficial Geology

The surficial geology is summarized below and presented on **Figure 2.2**. The information is reproduced from St. Onge (2009), supplemented with the DST logs and surface plans.

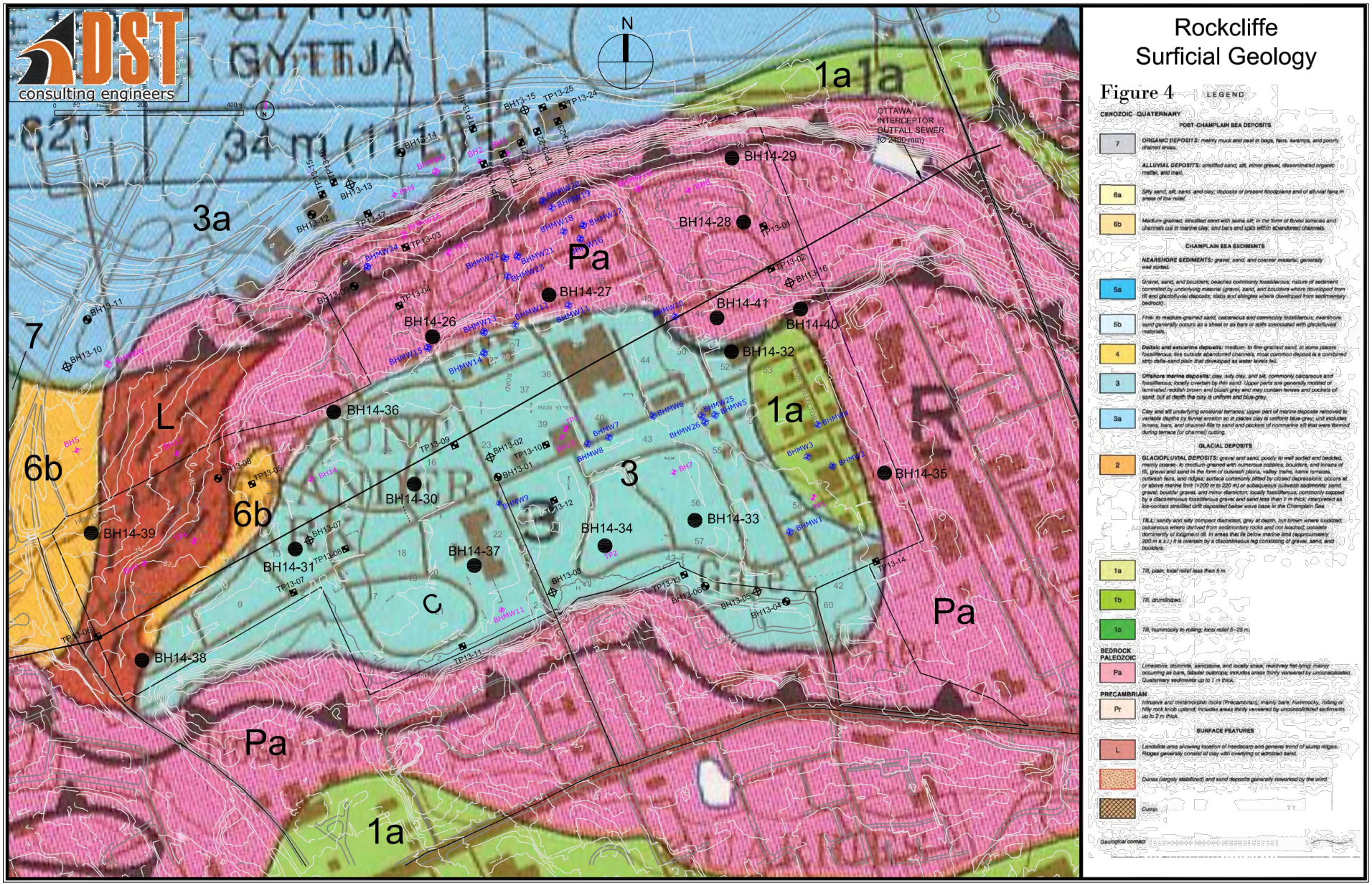
Bedrock is grey flat-lying limestone, generally unweathered except for the upper 1 m. The basal overburden consists of discontinuous remnants of till, composed of sand (average 67%), silt (average 26%) and clay (average 7%) with some gravel, olive to brown in colour (Kettles and Shiltz, in Fulton 1987). Much of the area is covered by Champlain Sea marine deposits of clay, silty clay and silt, commonly calcareous and occasionally overlain by a thin veneer of sand. Most of the clay is, in fact, not clay minerals but clay-sized (<2 µm) rock flour of quartz, feldspar, carbonate and amphiboles from source bedrock (Scott, 2003). Post Champlain Sea deposits consist of stratified sand with some silt, formed on fluvial terraces and in channels cut in marine clay, including former sand bars and spits (Gadd, in Fulton, 1987). The area marked "Pa" on **Figure 2.2** is characterized by shallow overburden (thickness less than 2 m) over Paleozoic limestone bedrock (Bélanger 2008), that covers approximately 17% of the site; and, elsewhere on the site, overburden thicknesses are up to 10 m (Belanger, 2008).

2.2.3 Site Stratigraphy

The former CFB Rockcliffe contains variable thicknesses and types of overburden materials overlying the bedrock. A shallow overburden soil condition (defined as less than 2 m of overburden thickness overlying bedrock) exists in several areas, covering approximately 17% of the site. In other areas of the site the overburden thickness ranges from greater than 2 m to about 10 m.

The native overburden comprises clay to silt marine deposits over the southern half of the site, silty to sandy till plain in parts of the western and northern portions of the site, and sand/silt alluvial sediments forming parts of the western portion of the site (**Figure 2.2**). Various fill materials are present from previous anthropogenic activities at the former CFB Rockcliffe site.

The generalized surface geology of the NCC-owned land between former CFB Rockcliffe and the Rockcliffe Parkway comprises marine sediments (clay/silt, sand) and fill material, with an overburden thickness of greater than 10m.



J:\32952–RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.2–Surficial Geology.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	SURFICIAL GEOLOGY	FIGURE 2.2

The following generally describes the overburden soil units at former CFB Rockcliffe.

2.2.3.1 Surficial Material and Topsoil

Grass and other organic material with roots extending about 10 cm below grade is present over much of the site, with topsoil extending up to about 20 cm in depth. Asphalt, with a thickness of about 10 cm, is present on existing roads and driveways.

2.2.3.2 Fill Material

Fill material consisting of silty sand, sand and gravel or clay is known to be present in various areas of the site. During previous field investigations by DST, fill was identified at many former development areas of the site, with fill thickness ranging from approximately 0.5 to 4.3 m (DST, 2006). Localized fill thickness greater than the observed values may exist. Fill material was also observed in several boreholes north of the site, at the bottom of the escarpment. There the fill, approximately 1 to 4 m thick, consists of compacted grey to orange coloured silt with sand and gravel. Concrete and asphalt materials were encountered within the fill.

2.2.3.3 Clay

Grey-coloured silty clay is the dominant natural overburden type in the central and southern portion of the site. The clay layer extends from near surface to a depth of more than 6 m in the south and thins out to the northeast and north where it overlies silty till deposits at depths of 1 to 2 m. Grey-coloured clay to silty clay with minor silt, sand and gravel was encountered in the NCC land north of the escarpment. The thickness of the clay was not determined.

2.2.3.4 Till

The northern and eastern portion of the site is generally underlain by till material consisting of grey-coloured compact silt, sand and minor gravel. Where encountered during previous drilling, the till is 1 to 3 m thick, underlying several metres of fill material.

2.2.4 Bedrock Geology

The former CFB Rockcliffe is underlain by bedrock from the upper Ordovician Formations, mainly East View Formation and Ottawa Formation (Urban Geology of Canadian Cities, GAC Special Paper 42) (**Figure 2.3**). Rock types in the East View Formation include shale, limestone, dolostone and siltstone. Rock types in the Ottawa Formation include limestone with some shaley partings and some sandstone in the basal part.

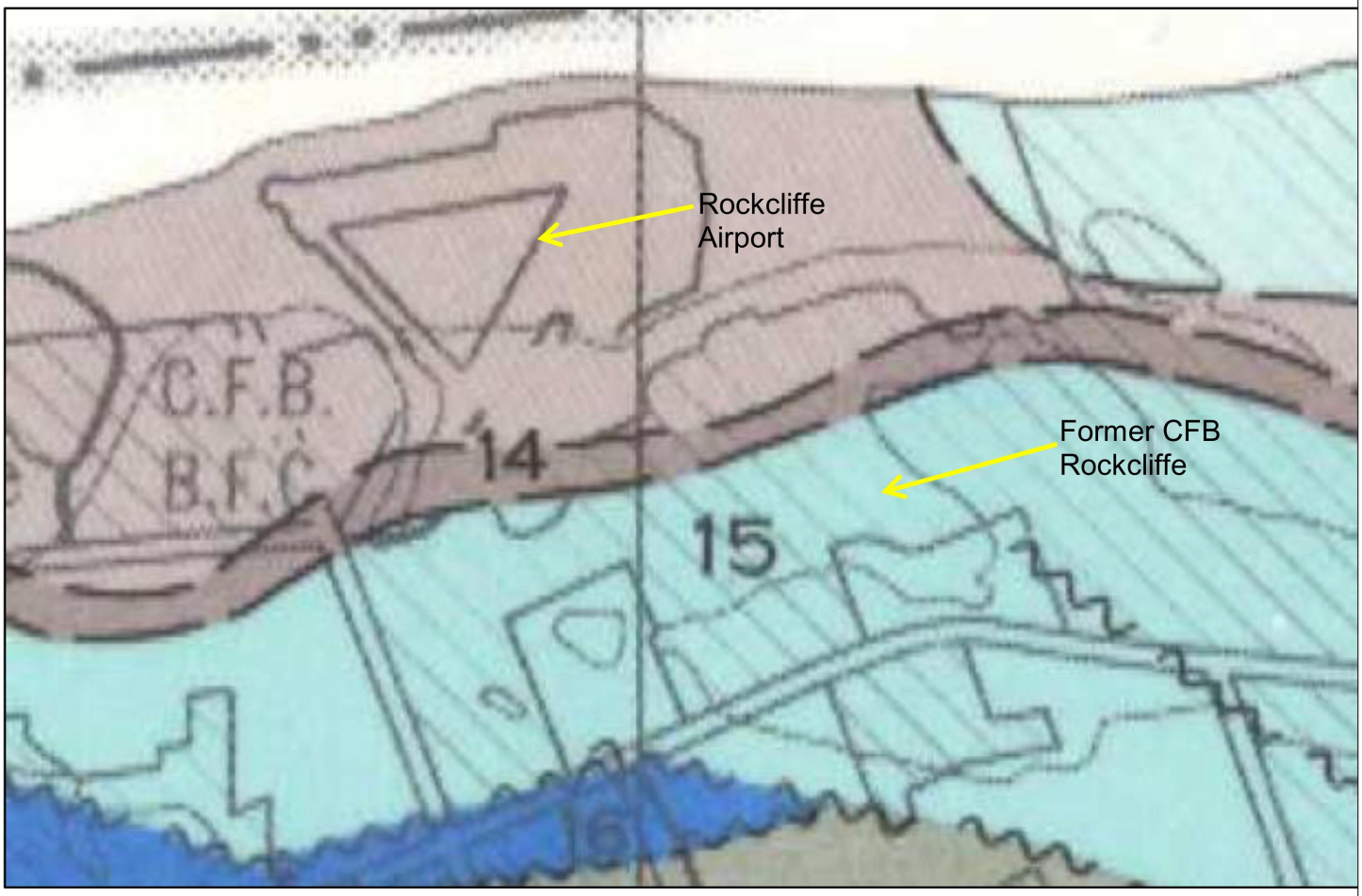
The Ottawa formation is subdivided into several formations such as Shadow Lake, Gull River, Bobcaygeon, Verulam and Lower Lindsay Formations. The formations, including East View Formation to Upper Lindsay Formation are often referred to as the Ottawa Group and middle to upper Ordovician in age.

During previous field investigations by DST, boreholes drilled into the bedrock at the Rockcliffe property typically encountered horizontally bedded, grey crystalline to fossiliferous limestone with minor narrow shale bedding, interpreted to be of the Ottawa Group. Minor narrow silt-fine sandstone beds were encountered within the limestone unit in one borehole (BHMW 12, 2004).

The bedrock surface is generally unweathered, or has a narrow weathering zone, less than one metre thick and occasionally limonite-stained. The northeastern portion of the site contains blocky (jointed) limestone in the upper 5 m of bedrock, and fault gouge was observed at depths of about 2.5 m and/or 4.5 m in several boreholes in the northeast of the property. **Figure 2.4** illustrates the bedrock contours of the site as determined by subsurface investigations as well as the test pit and borehole locations.

Hydrogeological Report
Stormwater Management Support Studies
Former CFB Rockcliffe, Ottawa, Ontario
DST Reference No.: OE-OT-017184

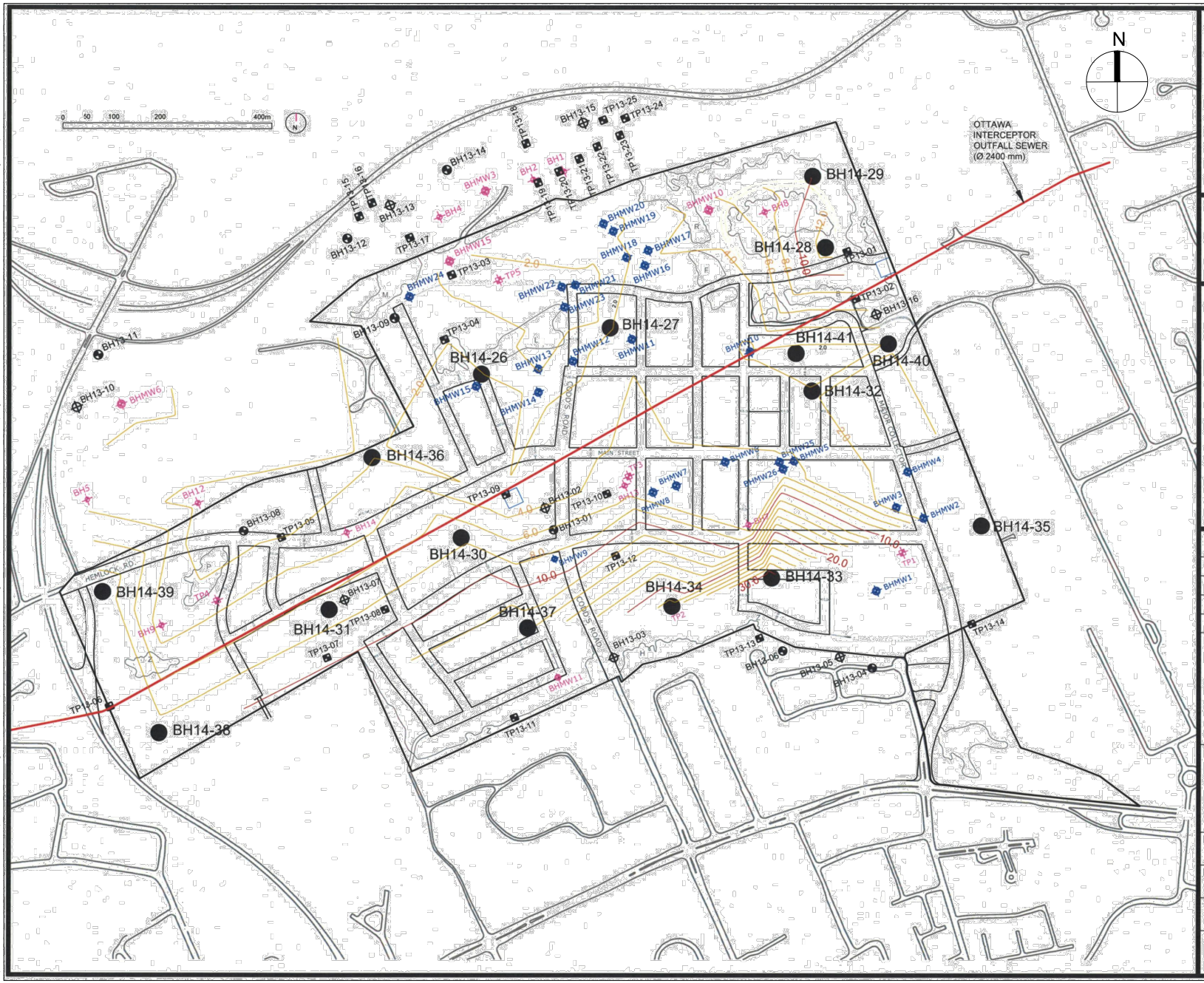
Plate 3.2: Bedrock Geology of the Former CFB Rockcliffe Area. (Generalized Bedrock Geology, GSC, 1976)



PALEOZOIC	15	OTTAWA FORMATION: limestone with some shaly partings: some sandstone in basal part
	14	ST. MARTIN FORMATION: shale, sandstone, impure limestone, dolomite
	13	ROCKCLIFFE FORMATION: shale with lenses of sandstone

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.3-Bedrock Geology.dwg Layout Name: Figure2.3

Project Title	Drawing Title	Sheet No.
FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	BEDROCK GEOLOGY	FIGURE 2.3



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LEGEND:
- MAJOR CONTOUR (10 m Interval)
- MINOR CONTOUR (2 m Interval)

REV	DATE	ISSUE	APPROVAL
0	APR. 10, 2014	Original	M.W.B.

PROJECT TITLE

Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE

BEDROCK DEPTH CONTOURS

DESIGNED BY B.V.	SCALE As Shown
DRAWN BY M.L.	DATE APRIL 2014
APPROVED BY M.W.B	PROJECT NO.: OE-OT-015358

Figure 9

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.4-Bedrock Contours Boreholes.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	BEDROCK CONTOURS, LOCATIONS OF TEST PITS AND BOREHOLES	FIGURE 2.4

2.2.5 Geotechnical Assessment

As noted in **Section 2.2.1**, several geotechnical investigation reports for the subject site have been completed by DST. The results of these reports were based on a subsoil investigation which included numerous test pits excavation and boreholes. The locations of these are included on **Figure 2.4**. The purpose of these investigations is to identify geotechnical/construction challenges and hazards and provide guidelines for various development elements such as infrastructure installation, roadway construction, building foundations, grade raises and stormwater facilities.

The geology and site stratigraphy were detailed in earlier report sections. In summary, the generalized stratigraphy for the east side of the site consists of asphalt surface treatment underlain by granular sand and gravel which is again underlain by silt or clay layer followed by bedrock. The generalized stratigraphy for the west side of the site consists of a thin layer of topsoil underlain by silty clay and sand and gravel layers followed by possible bedrock. **Figure 2.5** identifies the general location of the site overburden materials including clay and silt/sand; clay and sand/silt/gravel regimes.

2.2.5.1 Grade Raise Assessment

Most residential developments attempt to balance the management of existing soil material by establishing final site grades that are usually higher than existing site grades in an attempt to balance and accommodate expected site excavated materials. To assist and guide the development designers, the site geotechnical investigation reports review the ability of a particular site to accommodate site grade increases or grade raises. DST has completed such a review and the generalized grade raise limits are shown in **Figure 2.6**.

In order to limit potential subsurface settlement after site development, it is recommended that grade raises be restricted to a maximum of 2 m through the north and central parts of the site where bedrock overburden is shallowest. In other areas of the site that contain clay layers on top of the site bedrock, grade raises of 1 m are recommended. These recommendations are based on the results of the settlement analysis completed by DST. The details of the approach to establishing these grade raises are included in the above referenced DST reports.

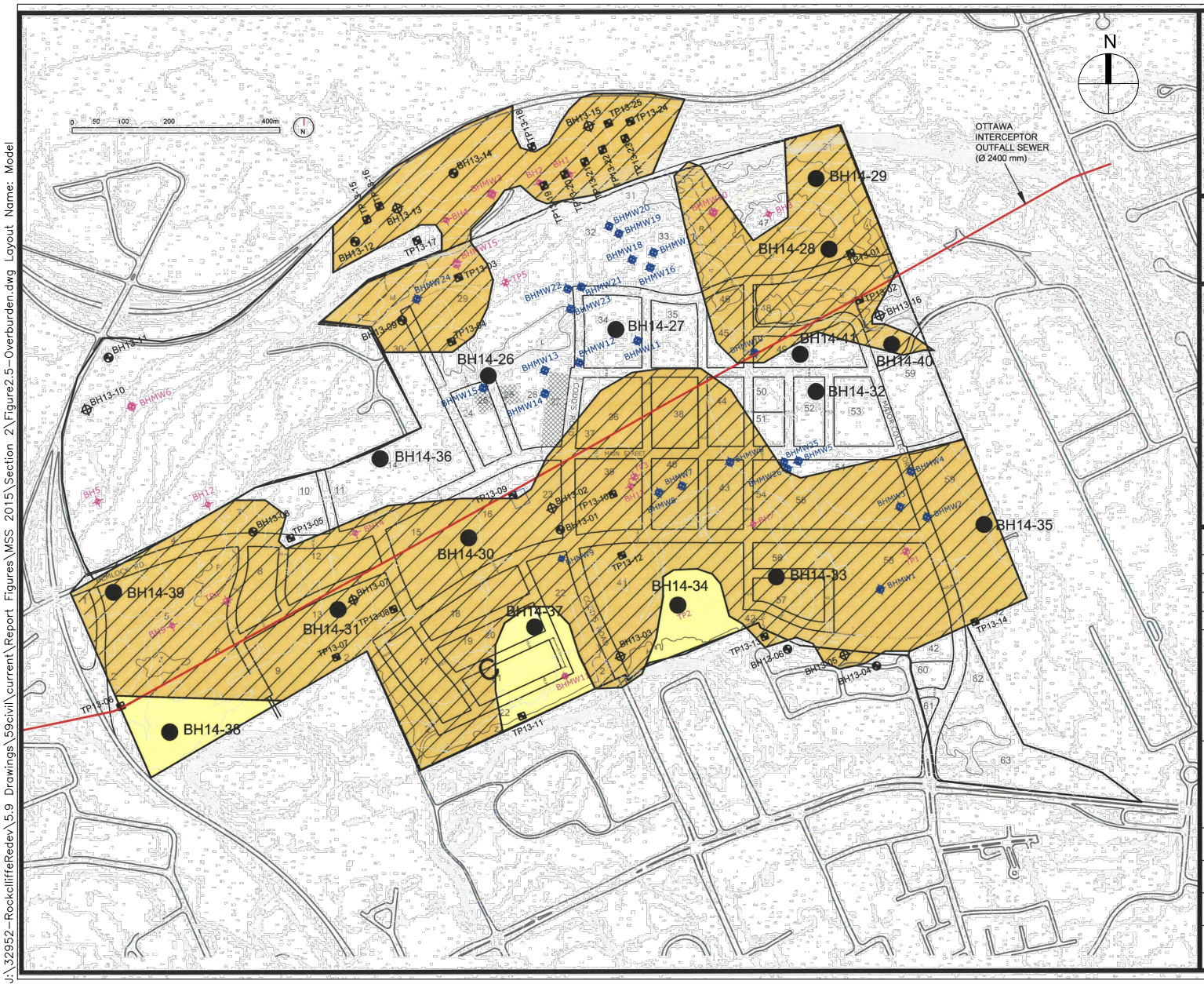
2.2.5.1.1 Grade Raise Impacts on Development

The geotechnical assessment of the impact of site grade raises assumed a limited amount of settlement and recommended that a reasonable criteria for differential settlement would be to not exceed 1:100 angular distortion. The details of this analysis are contained in DST's June 2014 "Community Design Plan Geotechnical Investigation" (DST File No. OE-OT-015358).

The predicted settlements as a result of the grade raise will impact the performance of residential and low rise development to be built on the site. However, the relative differential settlement within a single structure or group of structures will be minimal if grade raise plan is uniform across the property. Should a different grade raise plan/scenario be developed with very specific locations or areas of grade raise, site specific settlement analysis should be performed to confirm that the angular distortion and total settlement are within the tolerances.

2.2.5.1.2 Impacts on Streets

Settlement as a result of the grade raise will affect streets including sidewalks and curbs. Low speed limit roads are generally quite tolerant to settlement and settlement predictions indicate that differential settlement is acceptable since it is predicted it will meet the suggested reasonable criteria.



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LEGEND:
- CLAY & SILT/SAND
- CLAY
- SAND/SILT/GRAVEL

REV	DATE	ISSUE	APPROVAL
0	APR. 10, 2014	Original	M.W.B.

PROJECT TITLE
Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

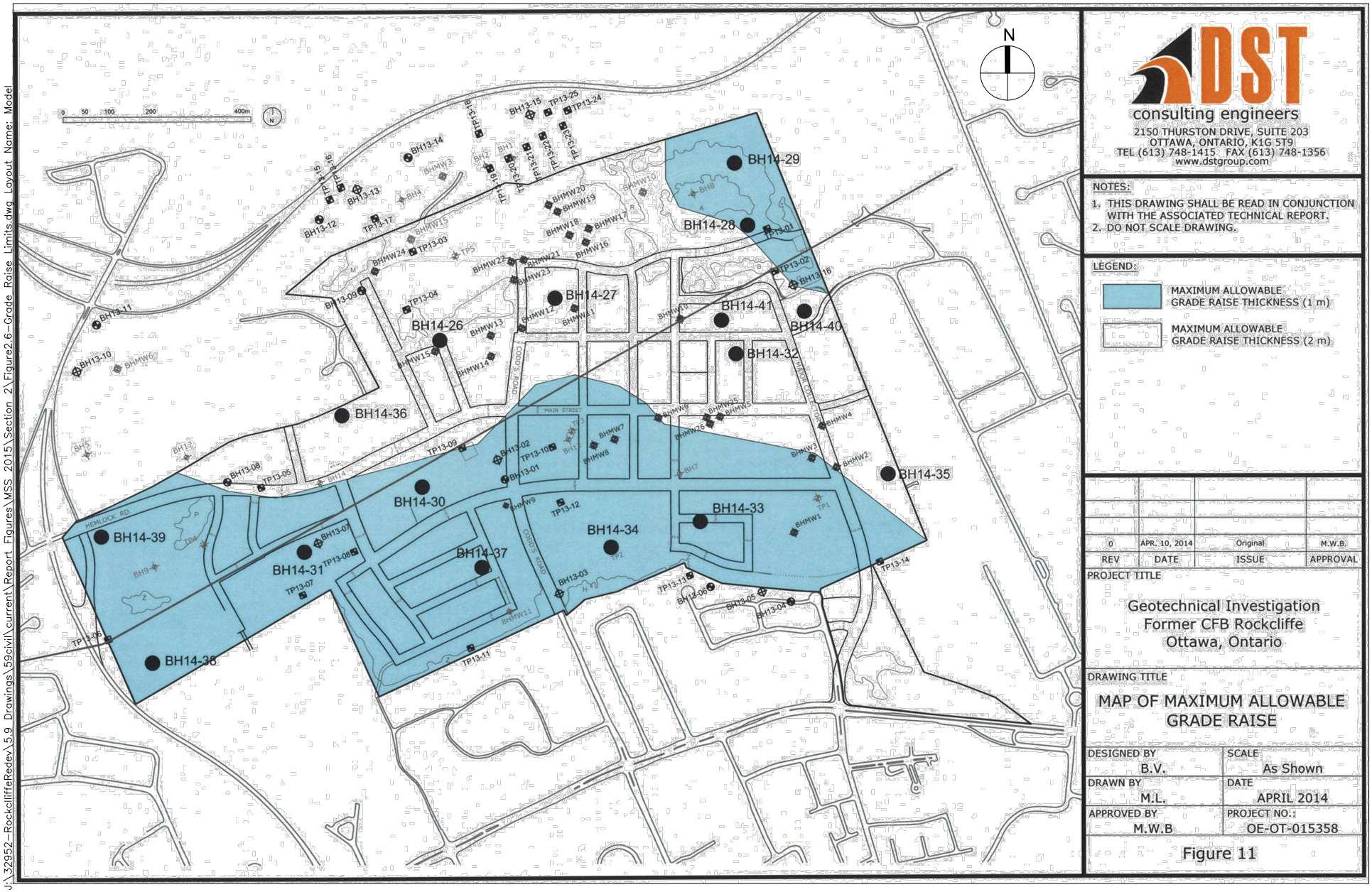
DRAWING TITLE
OVERBURDEN MATERIALS

DESIGNED BY B.V.	SCALE As Shown
DRAWN BY M.L.	DATE APRIL 2014
APPROVED BY M.W.B	PROJECT NO.: OE-OT-015358

Figure 8

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.5-Overburden.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	OVERBURDEN	FIGURE 2.5



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LEGEND:
- MAXIMUM ALLOWABLE GRADE RAISE THICKNESS (1 m)
- MAXIMUM ALLOWABLE GRADE RAISE THICKNESS (2 m)

REV	DATE	ISSUE	APPROVAL
0	APR. 10, 2014	Original	M.W.B.

PROJECT TITLE
Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE
MAP OF MAXIMUM ALLOWABLE GRADE RAISE

DESIGNED BY: B.V.	SCALE: As Shown
DRAWN BY: M.L.	DATE: APRIL 2014
APPROVED BY: M.W.B	PROJECT NO.: OE-OT-015358

Figure 11

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.6-Grade Raise Limits.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	GRADE RAISE LIMITS	FIGURE 2.6

2.2.5.1.3 Impacts on Buried Services

Given that the sewers and watermains will be buried within the streets, the street settlement will also be reflected as deflections in the pipes. Settlement predictions indicate that differential settlement is not expected to exceed the reasonable criteria for pipes. Service connections are not expected to be a problem if the buildings are designed to settle less than 25 mm under foundation loads alone.

2.2.5.2 Groundwater Recharge

2.2.5.2.1 Impacts to Groundwater Quantity

Groundwater on site flows from south to northwest, approximately following the local topography descending towards the Ottawa River. In general, the overburden water table is slightly higher than the bedrock groundwater surface across most of the property, with the exception of the top of the escarpment located in the northwest corner of the site.

In general, the development of surface infrastructures will decrease groundwater quantity as a result of decreased infiltration of precipitation. The change in volume of groundwater recharge by infiltration will be affected differently across the property by the development due to different types of overburden materials.

In the central and southern portions of the property, the silty clay overburden presently has very low infiltration rates and low hydraulic conductivity, therefore the development of relatively impermeable surface infrastructure in this area will not significantly decrease the quantity of groundwater recharge. The low hydraulic conductivity of the overburden unit will also impede the horizontal movement of groundwater away from any dry pond designed to promote infiltration, locally raising the water table in the area of the infiltration pond and reducing the capacity for further infiltration.

Development of relatively impermeable surface infrastructure on the till material underlying the northern portion of the property, and on the alluvial sediments underlying the western portion of the property, is in general expected to decrease infiltration and groundwater recharge. However, dry ponds designed to promote infiltration constructed in these materials are expected to effectively provide point sources for groundwater recharge. In this case, when runoff from the areas covered by clay material is diverted into infiltration ponds situated in areas with surficial deposits with higher infiltration rates, the actual groundwater recharge conditions for the area may improve compared to predevelopment conditions.

Impacts of site development (including remedial excavation and construction dewatering) in overburden deposits will be localized due to low permeability of deposits. Though temporary remedial excavation and construction dewatering in overburden is unlikely to impact existing wells, as a precautionary measure, groundwater elevation and quality monitoring in areas serviced by private wells such as the Fairhaven community and the Canadian Aviation and Space Museum is recommended before, during and after site development activities, in order to detect any potential impact in both the area of Fairhaven Way and the Aviation Museum. The groundwater elevation and quality program will include the following:

- a representative number of water samples will be obtained from the domestic wells on Fairhaven Way (up-gradient of the Site) and a sample from the potable well located at the Canadian Aviation and Space Museum (down-gradient of the Site).
- One groundwater elevation monitoring and sampling event will be completed prior to start of construction, which will be utilized as a baseline for background levels.

2.2.5.2.2 Impacts to Groundwater Quality

The development of the property as a residential community is expected to have negligible impacts on groundwater quality. Anthropogenic activities may introduce contaminants to water that recharges the groundwater under and downgradient of the property. Potential contaminants include, amongst others, polyaromatic hydrocarbons and salts. Certain areas of the property are also known to have contamination from its previous historic use as a military base (DST, 2006). An undertaking with regards to soils and groundwater remediation is being completed prior to redevelopment in the environmentally impacted areas. **Figure 2.7** indicates the areas of remediation within the subject site. The program is partially completed and could continue through 2015.

2.2.5.2.3 Impacts to Surface Water

Surface water flow measurements, completed on both the western and eastern creeks after a prolonged dry period, represent baseflow (groundwater discharge) conditions. Development at the property will have an impact on groundwater recharge conditions and may impact baseflow conditions in both creeks. As infiltration ponds enhancing infiltration to groundwater may be built in the area, potential impact on surface water is assumed to be minor.

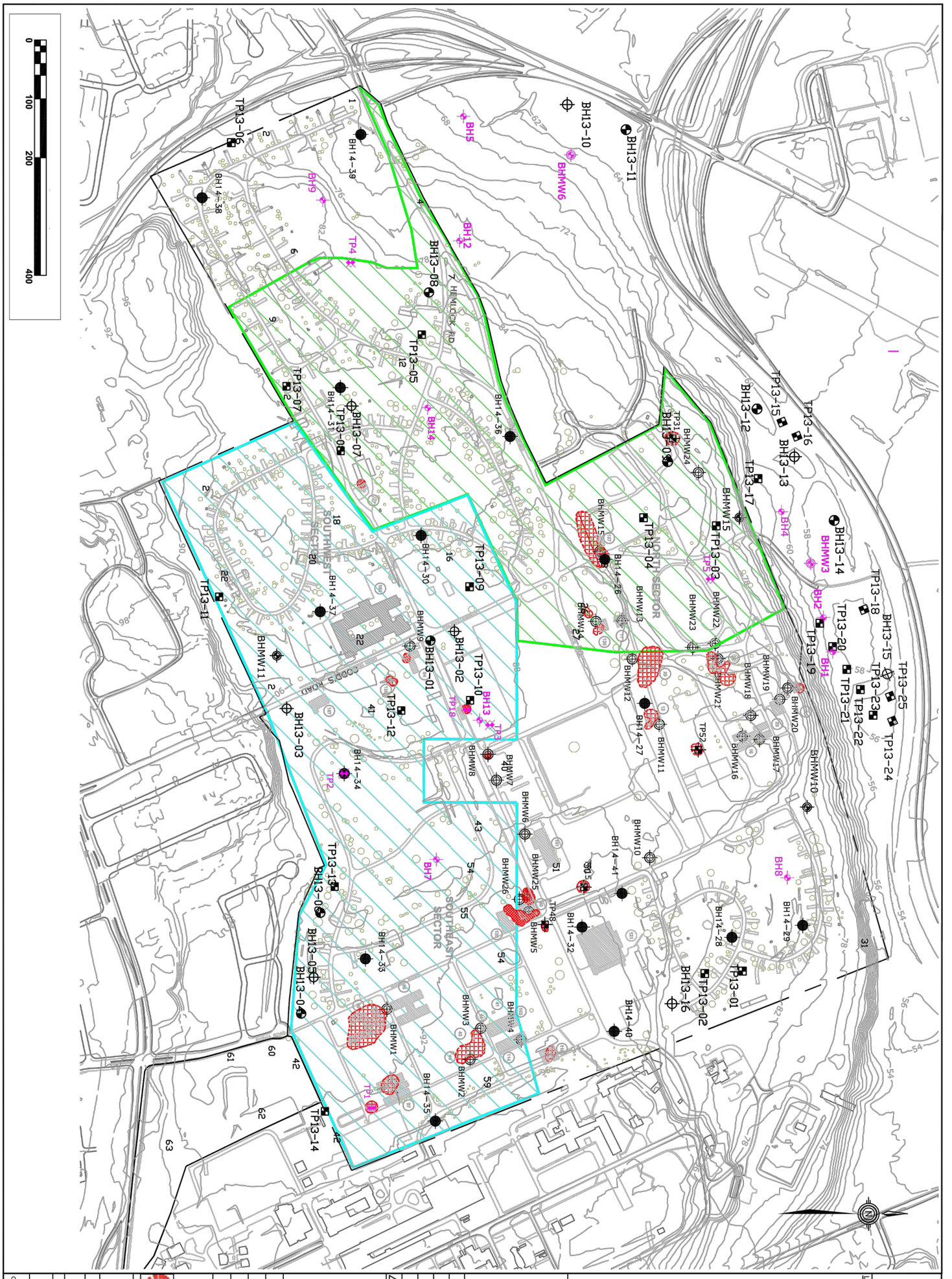
Previous assessment of the streams originating at the property suggest that there is no fish habitat present downstream of the property. Changes to baseflow resulting from changes to groundwater recharge at the property are therefore not expected to impact any fish habitat.

2.2.5.3 Stormwater Management Facilities

Based on the test hole information completed for the previous concept plan, it is considered feasible to design and construct the stormwater management facilities at the original off-site locations. However, the following preliminary elements will have to be considered in the design of each facility, referred to as the Western and Eastern SWM Facilities. At the time of the investigation, a conservative pond depth of 6 m was considered to ensure all potential geotechnical considerations were identified.

2.2.5.3.1 Western Stormwater Management Facility

DST has reviewed the data included within the Golder's geotechnical investigation for the proposed western stormwater pond (2015). Based on the data provided within this report, and only considering the current design of the proposed pond, a low-permeable membrane will be required to line the pond, and will require a counterweight (i.e. ballasts) to help minimize hydraulic uplift pressure (to prevent possible puncturing or floating of the liner). In order to install the liner, managing of groundwater infiltration into the pond during excavation and installation activities will be required. In order to be able to explore the most efficient method of groundwater management for short and long-termed control such as during the installation and operation stages, currently available hydrogeological information is being updated. Options will vary between a continuous well point system to minimizing groundwater inflow with an impermeable barrier. The magnitude and dimension of scale will depend upon findings from the in depth hydrogeology study. DST is currently conducting an additional investigation on the proposed western pond. This investigation includes additional boreholes (including packer tests), a slope stability analysis, an in-depth hydrogeology study, and recommendations which may include raising the pond depth for a potentially more suitable constructability. Nevertheless, the location as shown in the CDP will not be impacted, nor will this have any impacts on the development blocks or road pattern.



Sheet No.

Drawing Title

Project Title

Scale

FIGURE 2.7

REMEDIATION LOCATIONS

FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY

IBI

2.2.5.3.2 Eastern Stormwater Management Facility

The test holes at this location indicated the subsurface soils consists of sand fill, silty sand to sand and gravel to depths of 0.2 to 5.0 m underlain by silty clay to depths of 6.4 to 11.5 m overlying a till at 11.5 m. At the east end of the pond, the clay overlies a sand to silty sand at 6.4 m depth. The measured groundwater level was at 1.7 to 4.9 m.

At the proposed pond depth of 6 m below existing grade, it is expected that the base of the pond will be founded within the relatively impermeable silty clay layer. This soil, which has a low hydraulic conductivity value, seems to be suitable for a low permeability barrier at that depth with low potential of leakage provided artesian pressure does not exist at a shallower depth. However, the eastern portion of the facility will be founded in silty sand to sand material with higher hydraulic conductivities. This higher hydraulic conductivity material along the walls of the excavation/pond will produce a level of lateral seepage that may be unsuitable for the proposed design.

To maintain a wet condition in the pond, the silty clay base and sides of the pond are considered to be suitable since the clay is relatively impermeable with a low potential of leakage, provided artesian pressure does not exist at shallower depths. The sand to sand and gravel base and sides will permit lateral and vertical seepage that may be unsuitable for design of the pond. Therefore, a liner may be required in the east portion of the base of the pond and along portions of the walls or sides of the pond consisting of silty sand to sand and gravel.

2.2.5.4 Development Setbacks

The footprint of the future building structures must be set a safe distance from the crest of the north escarpment and the north boundary of Blocks 4, 6, 26 to 30. Safe setback distances should be determined during the final investigation based on an assessment of the slope conditions and type of building foundations. A preliminary opinion with respect to stable slope setback distance is provided. The assessment and opinion is based on a limited visual observation and review of limited subsurface geology at the proposed development site.

A review of the subsurface conditions and a visual inspection of the current surface conditions of the slope on the north escarpment, indicates that localized areas of bedrock are exposed along the face of the slope, mainly at the mid and lower section. The bedrock appears to consist of limestone interbedded with fractured shale. The shale shows evidence of erosion and a weathered condition. Fragments of the eroded shale can be seen accumulated on top of the blocks of the underlying limestone and along the slope face.

A preliminary slope stability analysis using typical value for critical state friction angle for the overburden material and strength equilibrium approach indicates a factor of safety is close to unity. This assessment does not consider the specific seismic hazard of the area.

Considering these geotechnical factors, the presence of silty clay, sand, silt and till and observed bedrock conditions, a preliminary stable slope allowance setback distance of 3 to 4 times the height of bank is recommended for overburden slopes and 1 time the height of bank is recommended for slopes with mainly exposed bedrock. The erosion allowance for the subject slope considering the subsurface soil materials encountered range from 5 to 10 m for the overburden soil and up to 10 m for the weathered bedrock. Thus the setback distances (stable slope allowance plus erosion allowance) for the subject site would range from 75 to 100 metres measured landward from the toe of the slope. Refer to **Figure 2.8** for locations of the preliminary set back limits. To assess more accurately the setback distance, further geotechnical investigation and slope stability analyses including an assessment of seismic effects (based on site classification of the site specific characteristics) will be required to confirm this preliminary assessment. The slopes should be monitored for any signs of instability. Should a reduction of the setback be required, site specific slope stability assessment would have to be carried out.

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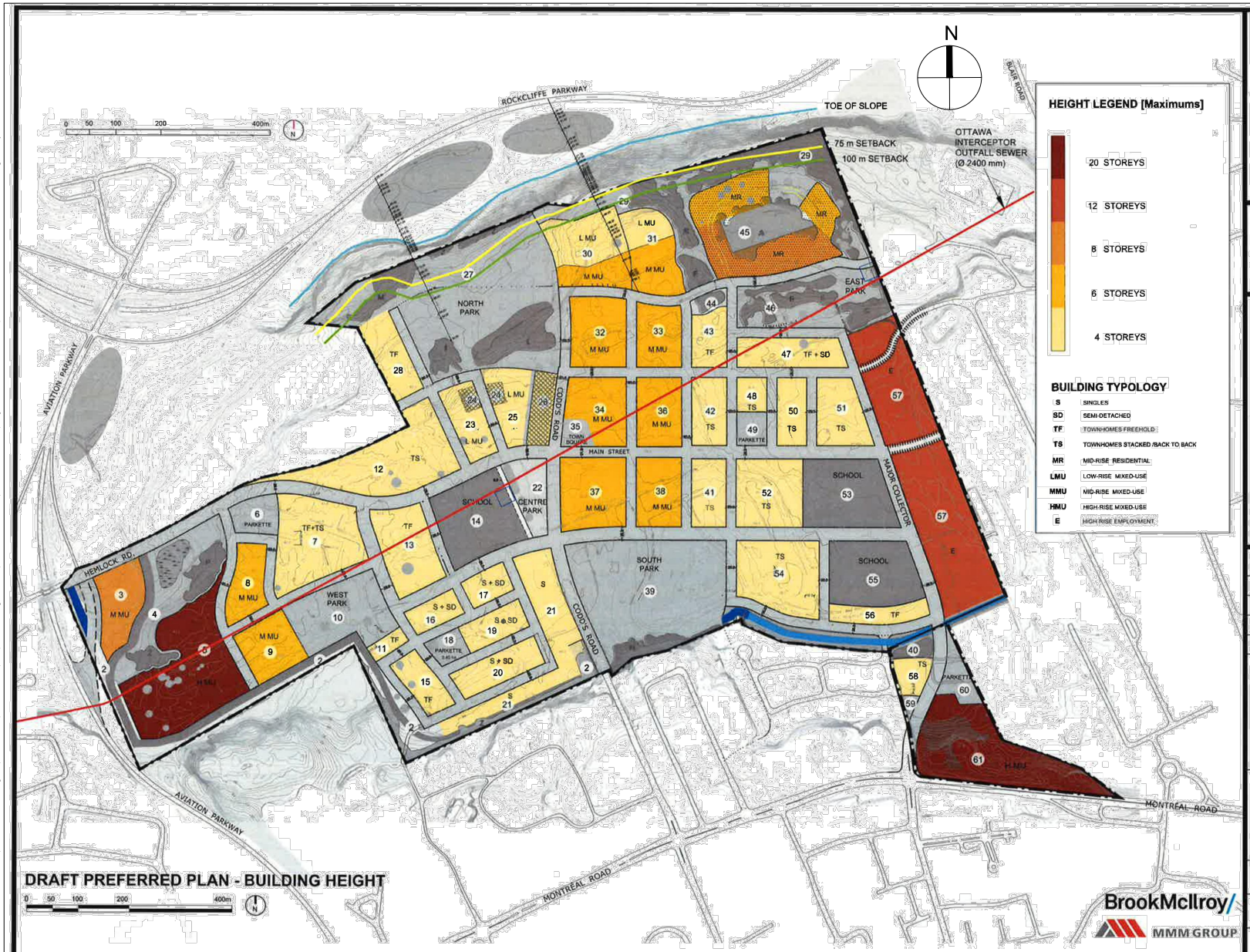

Base map and survey drawing provided by BrookMcIlroy/MMM GROUP

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LEGEND:
- Toe of Slope
- 75 m Setback
- 100 m Setback

REV	DATE	ISSUE	APPROVAL
0	MAR. 27, 2014	Original	M.W.B.

PROJECT TITLE
Geotechnical Investigation
Former CFB Rockcliffe
Ottawa, Ontario

DRAWING TITLE
SETBACK DISTANCES
NORTH ESCARPMENT

DESIGNED BY B.V.	SCALE As Shown
DRAWN BY M.L.	DATE MARCH 2014
APPROVED BY M.W.B	PROJECT NO.: OE-OT-015358

Figure 10

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	DEVELOPMENT SETBACK LIMITS	FIGURE 2.8

Slope stability analyses should be undertaken in accordance with the City of Ottawa document titled, “Slope Stability Guidelines for Development Applications”.

2.2.5.5 Wells

The Ontario Water Well Information System (WWIS) was reviewed for records of water wells located within and downgradient of the project site. The WWIS is a database of the Ontario Ministry of the Environment (MOE) records of water wells in Ontario, and is up-to-date to the end of 2012.

Four well records were found for the area downgradient of the project. Three wells drilled in 2007 are located at the Rockcliffe Airport, between the runway and the Ottawa River. One well is recorded as abandoned and the other two wells are noted as test holes, drilled to depths of 3.7 m and 4.9 m, respectively. No groundwater information is provided in these records.

There is one WWIS record for a well drilled in 2007 northeast of the Canadian Aviation and Space Museum. The status of this well is recorded as abandoned. There are no water wells located downgradient of the project site in the WWIS database that are recorded as in use.

Further to the above, DST made an inquiry to the City of Ottawa regarding municipal water supply to all adjacent areas to the project site. The response indicated that adjacent areas are serviced by municipal water, with the exception of the residences on Fairhaven Way and the Canadian Aviation and Space Museum, which are not on the municipal water supply. It is assumed that the Museum uses a local groundwater source, and is therefore a downgradient receiver of groundwater impacts from the project. The area of Fairhaven Way is located upgradient of the project site, where private wells utilize the bedrock limestone aquifer for domestic water supply.

Though temporary remedial excavation and construction dewatering in overburden is unlikely to impact these wells, as a precautionary measure monitoring of groundwater elevations and quality is recommended before, during and after site development activities, in order to detect any potential impact in both the area of Fairhaven Way and the Canadian Aviation and Space Museum.

2.3 Natural Environment

Aquafor Beech prepared the 'Stormwater Management Existing Conditions & LID Pilot Project Scoping' (May 2015). The report includes detailed environmental review in the form of stormwater management existing conditions, some of which is excerpted in the following sections.

2.3.1 Surface Water Features

There are three watercourses flowing within and around the former CFB Rockcliffe site:

- Western Creek
- Eastern Creek
- Northeastern Tributary to the Eastern Creek

The Western and Eastern Creeks serve as outlets from the site with respect to surface drainage and the existing storm sewers. The creeks flow to the Ottawa River via surface drainage, and pipes and culverts. The fluvial geomorphology assessment of the Western and Eastern Creeks is summarized in **Section 2.3.2** and the existing drainage of the site is discussed in more detail in **Section 2.4.3**.

2.3.2 Fluvial Geomorphology

The fluvial geomorphology of the Eastern and Western Creek systems under existing conditions were characterized in the 'Fluvial Geomorphology Assessment Study,' prepared by DST (September 2013). The Western Creek was determined to be geomorphologically stable, with most reaches lacking obvious signs of ongoing erosion. However, sub-reaches between Hemlock Road and the Aviation Parkway did show signs of instability, and a reach immediately downstream of a culvert north of the Aviation Parkway was deemed to be an eroding steep-walled gully with a very steep (5%) channel bed, incising into the consolidated clay base material. It is assumed that the channel was disturbed by flow from the existing culvert, leading to the destabilization of the downstream channel.

Unlike the Western Creek, the Eastern Creek has several sub-reaches that show signs of channel instability, including exposed roots on channel banks and oversized channel dimensions. The most upstream reach appears to be the most destabilized, which is likely attributable to the culvert under the Rockcliffe Parkway and resultant potential augmentation and/or grade change. In both creeks, it was observed that engineering works such as culverts have the potential to destabilize the channel. The recommendations of the Fluvial Geomorphology Assessment Study included the following:

1. It is imperative that any future SWM facility designs minimize perturbation of the Creeks.
    a. Western – estimated bankfull discharge is between 0.7 cms and 1.4 cms downstream of Aviation Parkway, upstream of the confluence.
    b. Eastern – estimated bankfull discharge is between 0.5 cms and 2.5 cms.
2. Implemented SWM facility design should not change the input discharge or sediment load to either creek.

2.3.3 Aquatic Ecology

An aquatic habitat assessment was undertaken for the Western Creek and Eastern Creek and presented in 'Aquatic Habitat Assessment Western and Eastern Creeks,' DST (August 2013). The assessment was undertaken to evaluate the potential impacts on aquatic habitat resulting from the management of stormwater for the site. The assessment was undertaken using the

Ontario Stream Assessment Protocol (OSAP) (Stanfield 2010), and it included examining five reaches of both the Western Creek and Eastern Creek (as indicated on **Figure 2.9**). Key findings included:

- Active Channel: Both the Eastern and Western Creek had an active channel width ranging from 0.5 to 2.0 m. Maximum bank height ranged from approximately 450 mm to 700 mm in the Western Creek and 350 mm to 750 mm in the Eastern Creek.
- Bank Angle: Overall, bank angles for both creeks range from 13° to 26°.
- Water Depth and Flow: The water depth during baseflow conditions in the Western Creek ranged from 52 to 105 mm while the Eastern Creek ranged from 0 to 46 mm. During baseflow conditions, both creeks can be characterized as having shallow flow depths and low flow velocities.
- Bank Vegetation and Instream Cover: The Western Creek was found to have low to moderate levels of bank vegetative cover throughout its length. Whereas, the Eastern Creek is characterized as having low to moderate levels of bank vegetation, it does display consistently high counts of instream cover (20 cover points/site), an important component of aquatic habitat for fish species. Cover is more varied in the Western Creek with higher levels of instream cover observed at upstream locations as compared downstream.
- Bank Undercuts: In general, the Western Creek displayed few severe bank undercuts, whereas the majority of the Eastern Creek displayed undercutting of the right bank. Other signs of erosion within the Eastern Creek including slumping banks were also noted.
- Water Temperature: Water temperature in the Western Creek was highest at the upstream but was considerably cooler in the deeper mid-reach sections of the creek. In general, water temperature in the Eastern Creek was highest at the downstream extent as compared to the upstream. Higher downstream water temperatures are likely a result of prolonged exposure to ambient air temperature due to the lack of outlet to the Ottawa River at the raised pedestrian walkway. The Aquatic Habitat Assessment indicated that temperature mitigation measures should not be required for the outflows from potential future SWM facilities proposed for the development.
- Macroinvertebrates: The community of macroinvertebrates was found to be moderately diverse, ranging from 9 to 15 taxa at each site. Key indicator species were mostly absent.
- Fish and Fish Habitat: Sites in the Western Creek appear to provide marginal fish habitat that could be suitable for some common fish species, however no fish were encountered during the fish surveys. It appears that the lack of connectivity to the Ottawa River (as the final 550 m of the creek runs subsurface) and extensive entombment of creek sections have prevented fish from reaching potentially suitable sites. The Eastern Creek could potentially provide habitat for species that are tolerant of low water levels (sticklebacks for example), though no fish were found during fish surveys. This is likely due to the fact that there was no downstream connection to the Ottawa River at the elevated recreational path and no upstream connection to other habitats.

  Moreover, the OSAP assessment indicated that the creeks did not support any rare or species at risk (SAR) varieties of invertebrates. Due to the poor quality of aquatic habitat and absence of significant open water, the report noted that it is highly unlikely that any wetland-associated SAR birds, reptiles, insects, or fish would be present within the survey area.

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LEGEND:

- CREEK LOCATIONS
- OSAP SURVEY LOCATION
- SITE BOUNDARY

NOTE:
1. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE ASSOCIATED TECHNICAL REPORT.
2. SOURCE - GOOGLE EARTH

REV	DATE	ISSUE	APPROVAL
0	09/08/13	FINAL	A.M.

PROJECT TITLE
AQUATIC HABITAT ASSESSMENT: WESTERN AND EASTERN CREEKS, FORMER CFB ROCKCLIFFE

DRAWING TITLE
SITE PLAN

DESIGNED BY: A.M.	SCALE: N.T.S
DRAWN BY: R.P.	DATE: August 2013
PROJECT MANAGER: A.M.	PROJECT NO.: OE-OT-017184
FIGURE No.: FIGURE 2	

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.9-Aquatic Habitat.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	AQUATIC HABITAT REACH LOCATIONS	FIGURE 2.9

2.3.4 Terrestrial Ecology

The terrestrial ecology investigations were completed for the preferred concept plan (refer to **Figure 1.3**). Due to topographical constraints, it was determined that the potential stormwater management facilities servicing the site would be most suitably located at a lower elevation. The terrestrial ecology investigations were completed to support this development concept.

Terrestrial ecology of the site and environs is supported by the following documents:

- CFB Rockcliffe Vegetation Survey Arborist's Report (Dan Baker, January 2013)
- Butternut Survey for Proposed Stormwater Ponds (DST, August 2013)
- Preliminary Terrestrial Habitat Assessment for Proposed Stormwater Ponds (DST, August 2013)
- Former CFB Rockcliffe Species at Risk Survey (DST, October 2014)

A summary of the findings of the background documents follows.

- Vegetation: it was noted that on-site native tree species identified include Sugar Maple, Basswood, Red Oak, White Pine, White Spruce, and White Cedar as well as Bitternut Hickory, Butternut, and Silver Maple. Non-native tree species identified on site include Black Locust, Norway Maple, Norway Spruce, Blue Spruce, and Weeping Willow. In general, the trees recommended for retention on the site are native trees, as some non-native species tend to be invasive (i.e. Norway Maple). However, some non-native trees are recommended for retention on the site.
- Terrestrial Habitat: The proposed location of the Eastern SWM Facility is within habitat that can be characterised as grassland immediately south of the Rockcliffe Parkway, with thick secondary growth deciduous forest growing around the base of the cliffs and cliff slope further to the south.
- Terrestrial Species at Risk: DST completed the Preliminary Terrestrial Habitat Assessment, which was used to determine the scope of subsequent SAR surveys completed for the Species at Risk Survey. The survey area considered the CLC property, the area north of the property where stormwater management infrastructure may be constructed, and the Eastern Creek.

  The Species at Risk Survey included consultation with the Ontario Ministry of Natural Resources; review of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and the Species at Risk Ontario (SARO) SAR status reports and range maps for the target species; review of the Natural Heritage Information Center (NHIC) mapping and historical records of SAR occurrences. In addition, the scope of work included identification of species-specific mitigation measures and discussion of anticipated SAR related permitting requirements. Mitigation and permitting information presented in this report should be reviewed and confirmed in the context of the more detailed impact assessments that will be undertaken as part of the forthcoming Environmental Impact Statement (EIS) and Environmental Effects Analysis (EEA) studies.

  Based on the above-noted records review, DST compiled a list of 24 SAR which may potentially be present within the survey area. Survey results indicate the presence of six species, as follows:

  - Butternut trees were identified at the CLC property, north of the property, as well as along the Eastern Creek. The Butternuts are classified as Category 1 (non-retainable, for example, terminally infected with Butternut Canker) or Category 2 (considered retainable). Most of these trees were clustered within the forest

patch growing along the edge of the escarpment. No Butternut trees were found within the grassland or within the proposed locations of the stormwater management facilities.

- The Monarch Butterflies were noted at three locations within fields containing Milkweed plants within the survey area. Due to the presence of Milkweed plants, it is presumed that Monarch Butterfly are both foraging and breeding within the survey area.
- Common Nighthawk were heard calling. It is presumed that Common Nighthawk may utilize the survey area for foraging purposes but no evidence of nesting behavior within the survey area was noted (calls were heard outside the survey area) and therefore, no significant habitat features were noted for this species.
- The Preliminary Terrestrial Habitat Assessment identified the potential that exposed rock crevices and rock cracks within the cliffs/exposed bedrock areas could serve as bat maternity roosting or hibernation habitats. The escarpment beyond the northern CLC property boundary is characterized by a steep drop in topography moving from south to north, with areas of exposed rock, rock crevices, and rock cracks creating unusual geologic conditions. Such features have the potential to serve as either summer roosting habitat and/or hibernation sites for some bat species. Three SAR bat species (Little Brown Myotis, Northern Myotis, and Tricolored Bat) were found to occur within the survey area. A comparatively small number of recordings were documented for each of these species, suggesting that while these species are present within the survey area, it is unlikely that a large colony exists for any of the SAR bats. The number of recordings observed for each species is similar to background levels of activity observed by DST for the SAR bats throughout the Ottawa area, and suggests that these species are utilizing the survey area and adjacent grasslands, meadows, and forested areas adjacent to the Rockcliffe and Aviation Parkways for foraging purposes only. It is also possible that small numbers of the SAR bats utilize rock crevices and cracks within the Rockcliffe Escarpment as summer roosting sites. Because all three SAR bats typically hibernate communally in sites with constant temperature conditions (e.g. caves, abandoned mines, large tunnels, etc.) and no large openings or caves have been noted within the escarpment, it is unlikely that the SAR bats would overwinter within the escarpment. There was not an observed significant increase in the number of recordings for the SAR bat species over the course of the survey, and no evidence of swarming activity within the survey area for these species was observed. Migratory Silver Haired Bats (not an SAR) increased in abundance towards the end of August, suggesting that this species is migrating through the survey area at that time.

  Due to the presence of potentially significant bat roosting habitat, which may serve as a summer roosting sites for small numbers of SAR bats and for larger numbers of Big Brown Bats, DST recommends that the future EIS/EEA should evaluate potential impacts to this feature. The Rockcliffe Escarpment is contained wholly within the NCC lands, and hence would be within federal jurisdiction. It should be noted that none of the SAR bats are currently listed under Schedule 1 of SARA, and hence do not require SARA-related permitting. Ontario Ministry of Natural Resources (OMNR) guidance dictates that bat hibernacula and roosting sites should be protected by a buffer of 120 m and that impacts to the habitat within 120 m of the feature should be considered as part of an EIS/EEA (OMNR 2011). Mitigation measures include pre-construction searches of any affected areas of the escarpment and a work timing window.

Several mitigation measures specific to the SAR identified have been outlined in the Species at Risk Survey report. The forthcoming EIS/EEA should elaborate on these mitigation measures to address other environmental impacts that are not specific to these species, as the list of mitigation measures outlined in the Species at Risk Survey report are not intended to address all potential environmental concerns. Ultimately, the EIS/EEA should include mitigation measures related to environmental impacts from the proposed undertaking.

- Provincially Designated Natural Areas: There are four provincially designated natural areas within one kilometer of the site; however the only area with the potential to be impacted by the redevelopment of the site is the Rockcliffe Airbase Woods. These woods are located northeast of the Rockcliffe Parkway and Airport-Marina Road and are characterized by a rolling landscape of deep marine clay that is lightly and irregularly covered by sand and silty sand and dominated by a young to submature upland deciduous forest. The underlayer of impervious clay has created complex moisture conditions across the site, resulting in equally complex variations in forest dominants. This site supports the largest clay-based upland area of relatively natural vegetation in Ottawa (NHIC, 2013).
- Urban Natural Areas: The City of Ottawa prepares reports on Urban Natural Areas (UNAs) within the City, detailing the fauna and flora, and the general health of the area. Within the vicinity of the former CFB Rockcliffe site, there are five UNAs: the Airbase Woods, the NRC Woods North, the Montfort Hospital Woods, the Carson Grove Woods, and the Assaly Woods.

  From an ecological standpoint, the two most valuable vegetated areas in the vicinity of the site are the Montfort Hospital Woods and the NRC Woods North. The Montfort Hospital woods are owned by the National Capital Commission. The City of Ottawa has confirmed that any development within 30 m of these features will require the completion of an Environmental Impact Statement (EIS).

Existing tree groupings and UNAs are indicated on **Figure 2.10** and Category 2 Butternut locations are indicated on **Figure 2.11**.

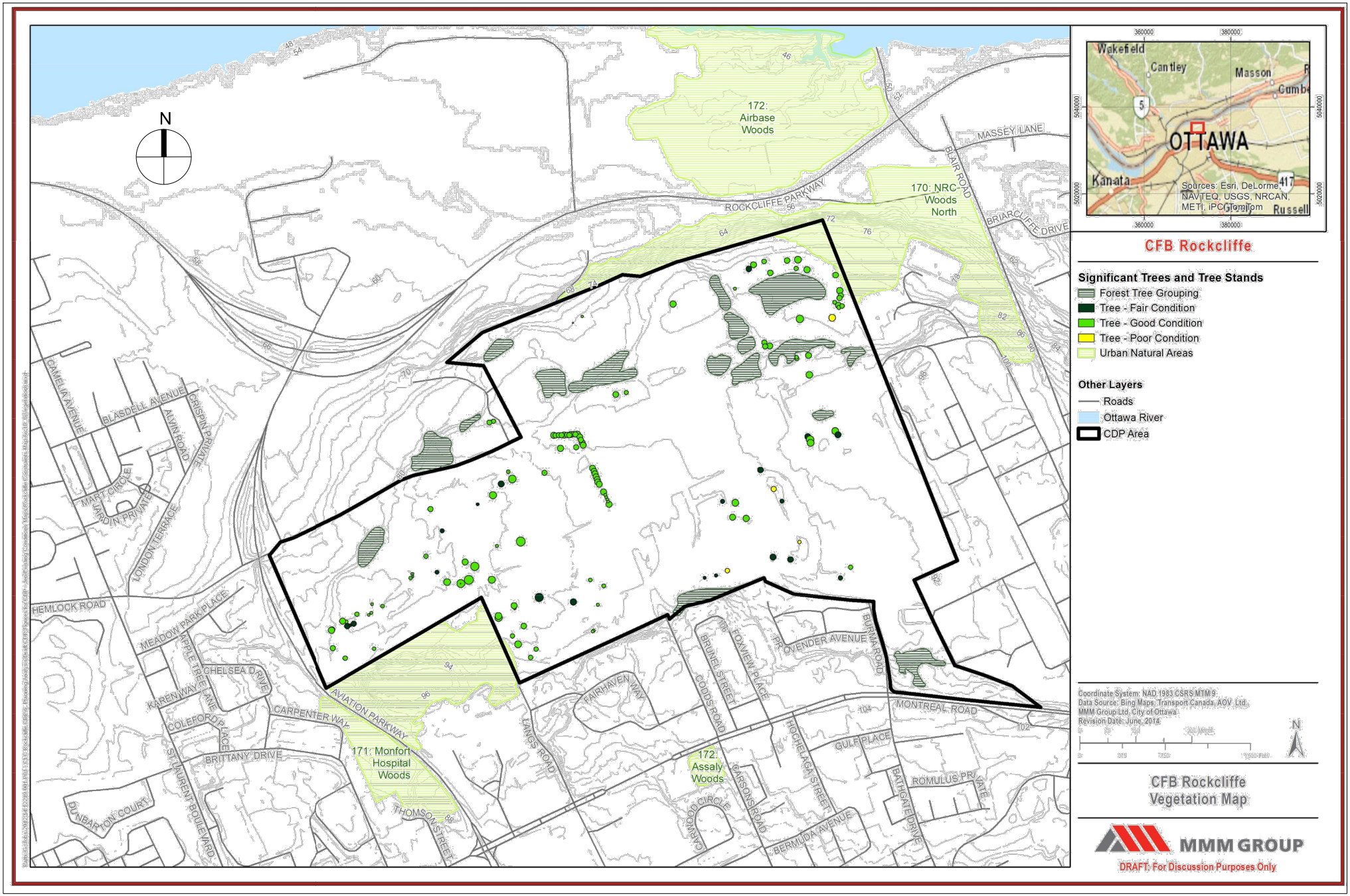
2.4 Municipal Servicing

2.4.1 Water

The Rockcliffe site is located in the City of Ottawa's Montreal Road Pressure Zone (MRPZ). The MRPZ is located on elevated lands within the City's Pressure Zone 1E and water pressure increases are required to provide adequate supply to the lands within the MRPZ. The site is serviced from two water pumping stations near Montreal Road. The Montreal Road Pump Station, located near Bathgate and Montreal Roads, supplies increased water pressure to a 400 mm/300 mm diameter watermain in Burma Road north of Montreal Road, which is the principal source of potable water to the Rockcliffe site. The Brittany Drive Pump Station, located to the west near Brittany Drive and Montreal Roads, is primarily used as a backup or secondary feed to the MRPZ, and would supply water to the 400 mm/300 mm Burma Road watermain in the event of a failure of the Montreal Road Pump Station. The existing water supply and distribution system for the Rockcliffe site is shown on **Figure 2.12**.

Because of the elevation drop between Montreal Road and the study area, a pressure reducing valve assembly was installed near the northern end of the Burma Road 400 mm diameter watermain immediately below the southern escarpment near Canopy Street.

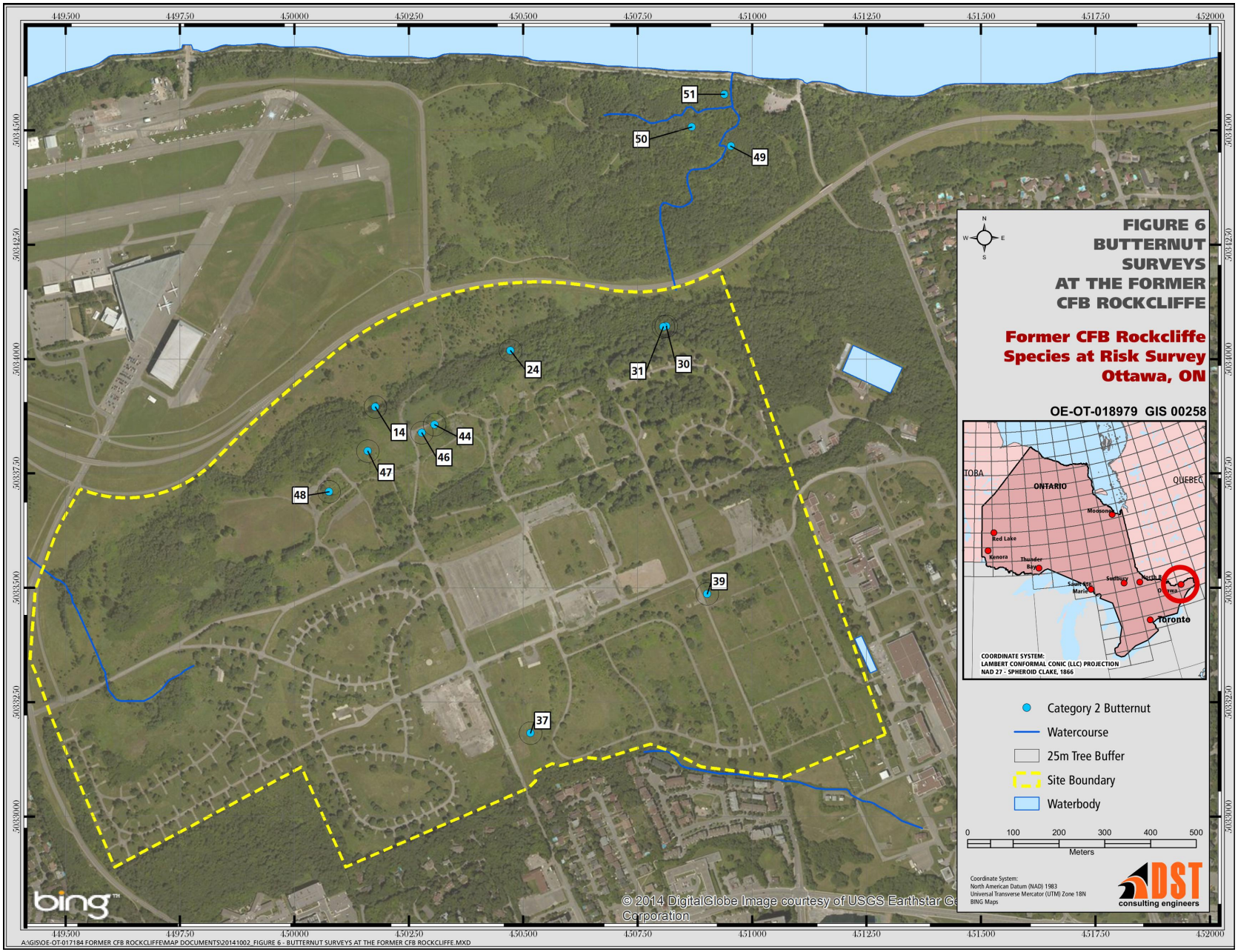
As well, it is noted that there are two 300 mm diameter watermains feeding the NRC Campus from Burma Road just north of the Montreal Road Pump Station. It is understood that the old



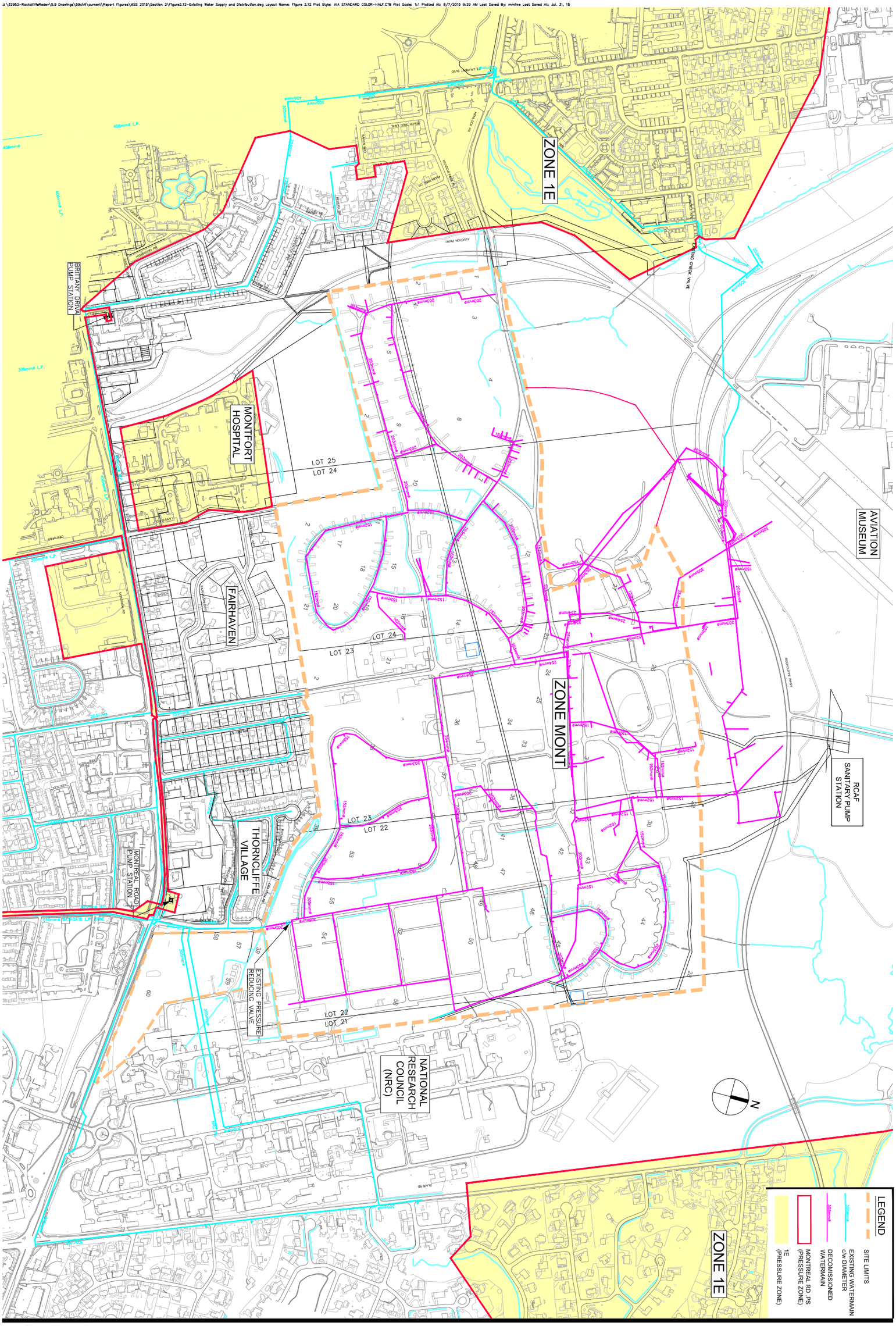
J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.10-Existing Tree Grouping And UNAs.dwg Layout Name: Model

Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	EXISTING TREE GROUPINGS AND URBAN NATURAL AREAS	FIGURE 2.10

J:\32952-RockcliffeRedev\5.9 Drawings\59civil\current\Report Figures\MSS 2015\Section 2\Figure2.11-Butternut Locations For SWM Facilities.dwg Layout Name: Model



Scale	Project Title	Drawing Title	Sheet No.
NTS	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	BUTTERNUT LOCATION PLAN	FIGURE 2.11



Sheet No.

FIGURE 2.12

Drawing Title

EXISTING WATER SUPPLY AND DISTRIBUTION

Project Title

FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY

Scale

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connection from near the Aviation Museum to Blasdell Avenue (connecting the MRPZ and Zone 1E) has been abandoned and is no longer in service.

The local distribution system within the study area consists of 150 mm to 200 mm diameter watermains. These mains are also shown on **Figure 2.12**. It has previously been concluded that the existing system will be replaced during the Rockcliffe site redevelopment since roadway networks will be different and the existing supply system will not be capable of supporting the proposed redevelopment to current City of Ottawa standards. The existing site watermains are no longer in service.

Most of the adjacent neighbourhoods surrounding the Rockcliffe site are serviced by the City's potable water supply system. These include the NRC Campus, Thorncliffe Village, Foxview and the Montfort Hospital. However, Fairhaven, a small neighbourhood located immediately to the east of the Montfort Hospital Woods, is serviced by individual wells and is not connected to the City's municipal supply. It is understood that the Fairhaven neighbourhood wishes to remain on wells and that redevelopment of the Rockcliffe site's water supply and distribution system should not consider any municipal piped water supply to this neighbourhood.

2.4.2 Wastewater

All collected wastewater flow in the City of Ottawa is routed to a central treatment plant, known as the R.O. Pickard Environmental Centre, which is located several kilometers to the east of the Rockcliffe site. Wastewater flows are delivered to the treatment plant by several large trunk sewers including the Ottawa Interceptor Outfall Sewer (IOS) which flows through the middle of the Rockcliffe site in a west to east direction. This major collector sewer is 2.4 m in diameter and was constructed approximately 45 m below the existing ground surface. **Figure 2.13** shows the location of the IOS trunk sewer as well as the location and sizes of the sanitary sewer system in and around the Rockcliffe site.

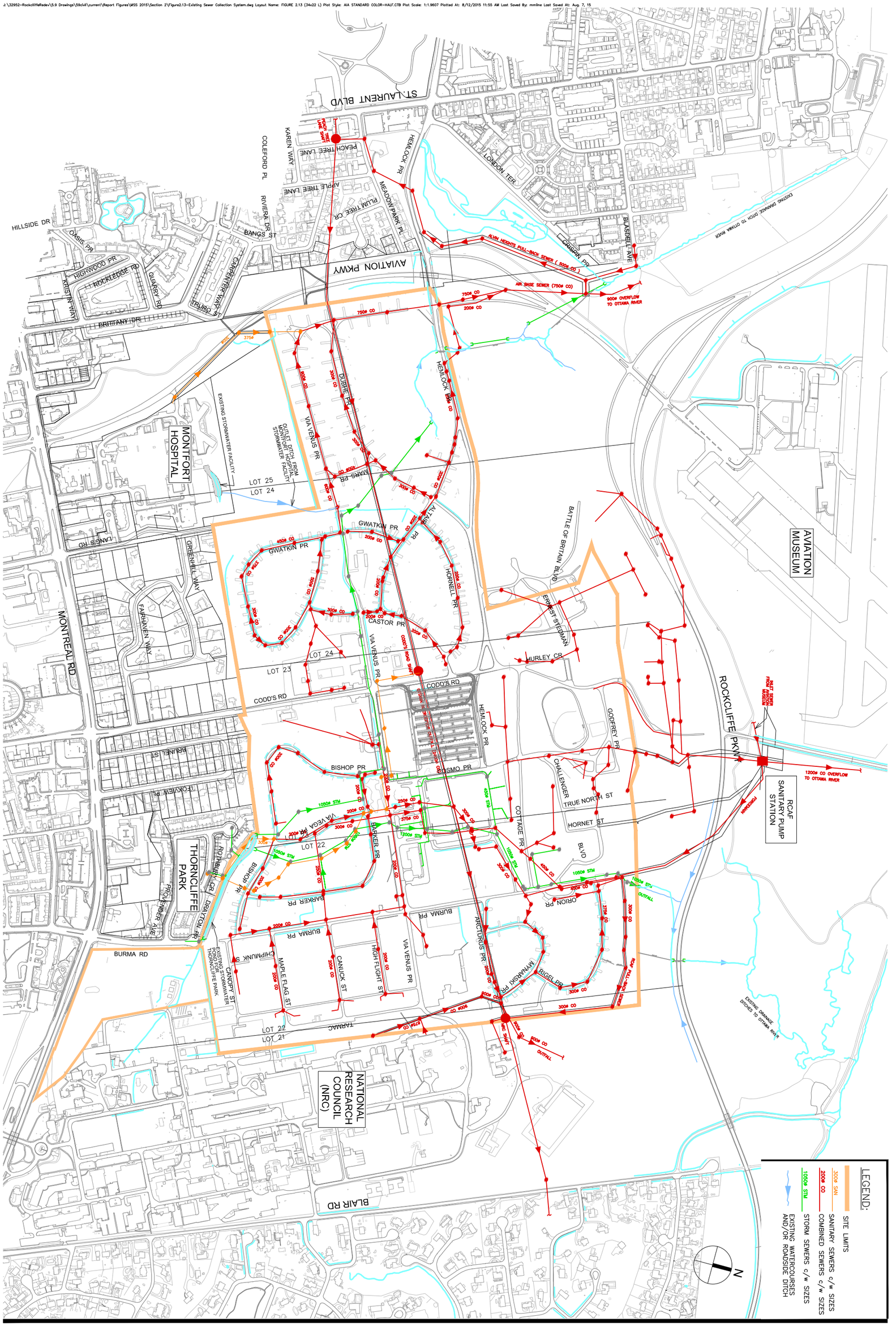
The existing sewers within the site consist of mostly combined sewers carrying both wastewater and storm runoff. There are only two dedicated storm sewer systems within the site and two short sections of dedicated sanitary sewers which carry sanitary flows from two external areas to the site. These dedicated sewers are also illustrated on **Figure 2.13**.

All combined sewage from the Rockcliffe site is discharged to the IOS trunk sewer. The combined sewers on the site located west of Codd's Road presently outlet to the Alvin Heights Pull-Back Sewer via the 750 mm diameter Airbase Outlet Sewer. The Alvin Heights Pull-Back Sewer eventually connects to the IOS trunk at the Peach Tree Road Shaft. The combined sewers to the east of Codd's Road outlet to the RCAF Pull-Back Sewer, which connects to the IOS trunk sewer at the NRC Shaft.

Both connections to the IOS trunk sewer also contain overflow mechanisms directing dry weather flows to the IOS trunk sewer and discharging some flows to the Ottawa River during major wet weather events. The overflow structures help control surcharging in the IOS trunk sewer beyond the Rockcliffe site.

The remaining combined sewers on the site, located near the north central portion of the site, which are identified as combined sewers on **Figure 2.13** but without any size identifications, are no longer in active service but continue to outlet to the RCAF Pump Station located east of the Aviation Museum and north of the Rockcliffe Parkway. The museum also outlets to that pump station which in turn is connected to the RCAF Pull-Back Sewer via a forcemain system.

The 2013 Infrastructure Master Plan Wastewater Collection System Assessment report includes a discussion on the capacities and duties of the City's wastewater pump stations, including the RCAF Pump Station. Table 6.2 on Page 6.6 of that study indicates that the pump station has a firm capacity of 29 l/s but is currently only pumping about 2 l/s. A copy of the table is included in **Appendix B**.



Sheet No.	Drawing Title	Project Title	Scale
FIGURE 2.13	EXISTING SEWER COLLECTION SYSTEM	FORMER CFB ROCKCLIFFE MASTER SERVICING STUDY	0 100 200

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