Approved by the Municipal Planning Commission

August 12, 2014

RIVERSTONE PHASES 17, 21 AND 22

OUTLINE PLAN AMENDMENT

Stantec

City of Lethbridge

RIVERSTONE PHASES 17, 21 AND 22

OUTLINE PLAN AMENDMENT

June, 2014

Prepared for:
CITY OF LETHBRIDGE RELD
Lethbridge, AB

Prepared by:
STANTEC CONSULTING LTD.
Lethbridge, AB

Project No. 112935574

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1.0 INTRODUCTION

The RiverStone Outline Plan (OLP) Amendment is being prepared on behalf of City of Lethbridge Real Estate and Land Development (RELD). The Outline Plan Amendment area encompasses Phases 17, 21 and 22 in the SW corner of RiverStone (SW ¼ SEC 24-8-22-4 and NW ¼ SEC 13-8-22-4). Currently the area is bisected by the existing 40th Street Road R/W that leads to the communities of Paradise Canyon and Canyon Crest. **Figure 1.0 Area Context Plan** highlights the surrounding communities and amendment area.

The original RiverStone Outline Plan as approved by the City of Lethbridge is included in **Appendix A** and this amendment will describe the proposed land use reclassification/layout and the corresponding impacts to the plan area. In addition, the plan will include the following key topics for the Amendment Area:

- Land Use Statistics and Classifications
- Transportation Network (Road Classifications and Transit Route)
- Water Distribution System and Connection Points
- Sanitary Sewer Collection System and Connection Points
- Storm Water Management System and Connection Points (Minor System)
- Storm Water Management System: Conceptual Grading, Overland Flow and Trapped Lows (Major System)
- Open Space System
- Geotechnical Report (Appendix C)

All municipal infrastructure systems discussed within this document have been developed under current City of Lethbridge Design Standards and Alberta Environment Guidelines.

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Legend

- Phase Boundary
- Outline Plan Amendment Area
- Developed / Sold
- Future Development
- Open Space Parks, School
- Pond and Creek

RIVERSTONE OLP AMENDMENT | FIGURE 1.0

Area Context Plan

PREPARED FOR: CITY OF LETHBRIDGE - RELD

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2.0 LAND USE STATISTICS AND CLASSIFICATIONS

The RiverStone OLP Amendment area is comprised of approximately 16.24 Ha of land and is currently zoned FUD (Future Urban Development) and R-L (Low Density Residential). The current City of Lethbridge Land Use District Map is included in Appendix A and our proposed Land Use classifications have been identified on **Figure 2.0: Proposed Land Use**.

The key alterations to the previously submitted Outline Plan Amendment (June 2013) include:

- Removal of multi-family parcels from the plan area.
- The development of a new single detached component and local road Network.
- The addition of a 0.30 ha open space that will be developed as a dog park.
- The development of a Storm Water Management Facility that will service approximately 11 Ha of the Plan Area.

This redefined layout continues to follow the intent of the originally proposed land use, except for the creation of the Storm Water Management PUL which has been added to the area based upon current City of Lethbridge Requirements for storm water drainage. Proposed Residential Land Uses include additional R-L (Low Density) and R-CL (Comprehensively Planned Low Density Residential). Refer to **Table 2.1 Land Use Summary and Statistics** for a summary of new land use statistics.

TABLE 2.1 LAND USE SUMMARY AND STATISTICS (Amendment Area Only)

Land Use and Population Estimates	Area (Ha)	Area (Ac)	% of GDA
Gross Area	16.24	40.13	
Environmental Reserve	0.00	0.00	
Gross Developable Area	16.24	40.13	
Public Land Use			
Public Right of Ways	4.41	10.90	27.2%
Storm Water Management Facility (Includes HWL)	0.62	1.53	3.8%
Parks and Recreation (P-R)	0.30	0.74	1.8%
Public Subtotal	5.33	13.17	32.8%
Net Developable Area	10.91	26.96	
Residential			
Low Density Residential (R-L)	5.44	13.44	33.5%
Low Density Residential (R-CL)	5.47	13.52	33.7%
Residential Sub Total	10.91	26.96	67.2%
Total	16.24	40.13	100.0%

	Population Estimates			
	Density (UPH)	Density (UPA)	Total Units	Area Population
Low Density Residential (R-L)	20	8	109	305
Low Density Residential (R-CL)	25	10	137	383
Residential Sub Total			246	688

	Ha	Acre
People/GDA	42.4	17.1
People/NDA	63.1	25.4
Density/GDA	15.1	6.1
Density/NDA	22.5	9.1

Notes:

UPH-Units per Hectare

UPA-Units per Acre

HWL-High Water Level

Low Density Residential 2.8 people/Unit (West Lethbridge ASP 2)

Land Use Calculations exclude Neighboring Arterial Roadways

As land use statistics were not completed for the original OLP, a detailed comparison cannot be made. However, given the elimination of the multi-family component and the addition of the PUL and MR, population and density will be lower than originally anticipated which will result in less impact to existing infrastructure.

Land Use and Population Estimates	Area (Ha)	Area (Ac)	% of GDA
Gross Area	**16.24**	**40.13**	
Environmental Reserve	**0.00**	**0.00**	
Gross Developable Area	**16.24**	**40.13**	
Public Land Use			
Public Right of Ways	4.41	10.90	27.2%
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	Ha	Acre
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People/NDA	**63.1**	**25.5**
Density/GDA	**15.1**	**6.1**
Density/NDA	**22.5**	**9.1**

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Legend

- RiverStone Outline Plan Amendment Boundary
- Low Density Residential (R-CL)
- Residential - Low Density (R-L)
- Parks and Recreation (P-R)
- Storm Water Management (SWMF)

RIVERSTONE OLP AMENDMENT | FIGURE 2.0

Proposed Land Use
& Statistics

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3.0 TRANSPORTATION NETWORK & TRANSIT ROUTES

Road Rights of Way within the plan area are comprised of a community entrance that transitions to an existing 23m major collector. All other roadways will be classified as local.

Transit routes are preferably placed on public collector roadways. A route may be placed on a local road either temporarily or permanently depending on the circumstance and at the discretion of the Transit Manager. Public collector roadways will be designed to meet the current City of Lethbridge Design Standards to ensure adequate space and durability for transit vehicle passage. Transit routes and stop locations will be determined as the neighbourhood develops and may be subject to change. Transit Standards may change between the OLP approval and the implementation of a transit route in a new neighbourhood. **Refer to Figure 3.0 Transportation Network.**

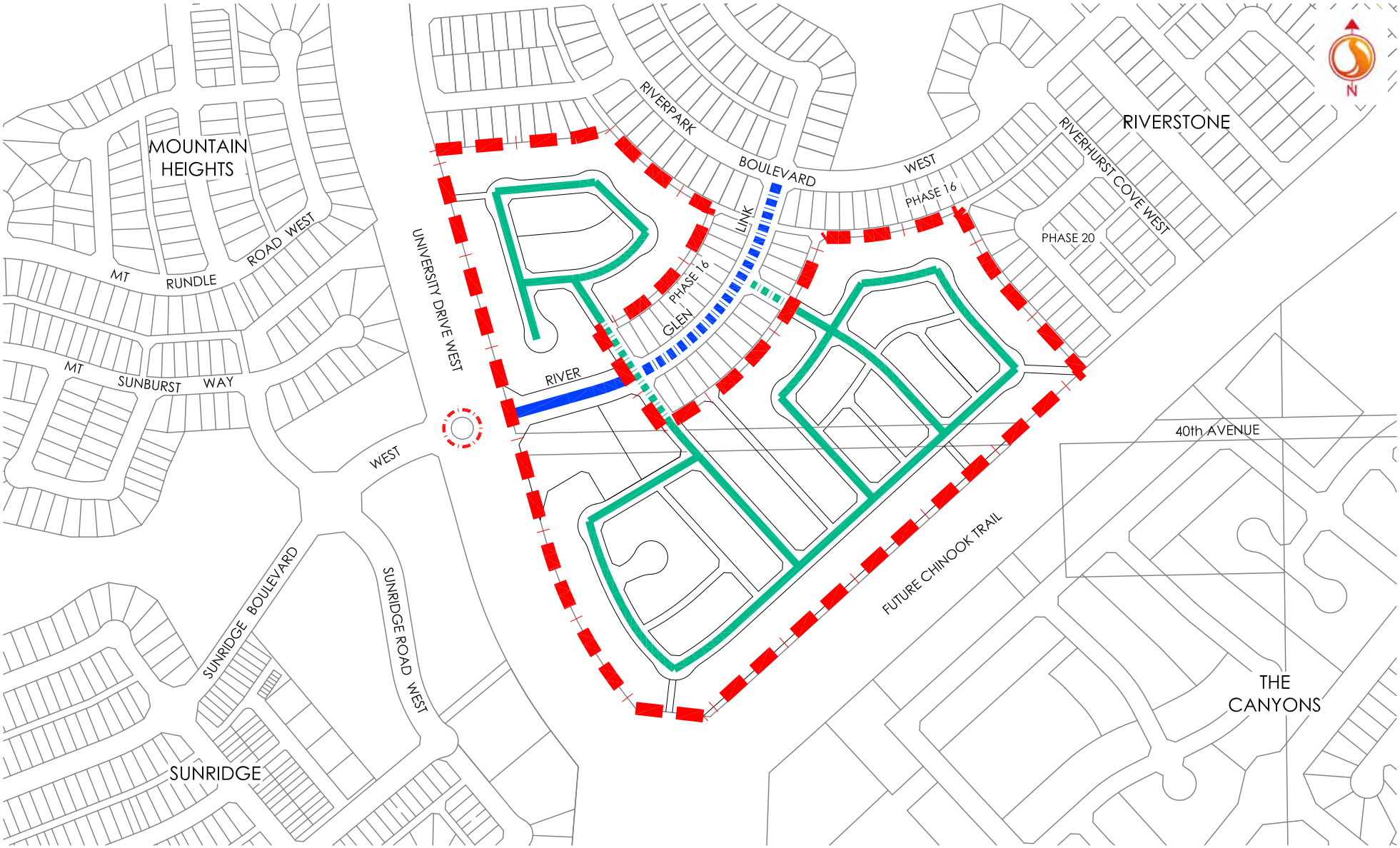
4.0 WATER DISTRIBUTION SYSTEM

A water distribution system has been outlined on **Figure 4.0 Water Distribution and Connection Points** along with key connections to existing systems (University Drive and River Glen Link) and future systems (RiverStone 20). The River Glen Link line will continue with a 250mm diameter water line and all other lines will be 200mm diameter. **Table 4.1 Estimated Water Demands** identifies the estimated water demand for the OLP Amendment Area.

TABLE 4.1 ESTIMATED WATER DEMANDS

Average Day Demand (415L/cap/day)	0.29 ML/day
Maximum Day Demand (2.2 x ADD*)	0.63 ML/day
Peak Hour (3.5 x ADD)	1.01 ML/day

*ADD – Average Day Demand



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Legend

- RiverStone OLP Amendment Boundary
- Community Entrance
- Existing 23m Major Collector
- Future Local Road
- Existing Local Road
- Existing Roundabout

RIVERSTONE | FIGURE 3.0

Transportation Network

Outline Plan Amendment

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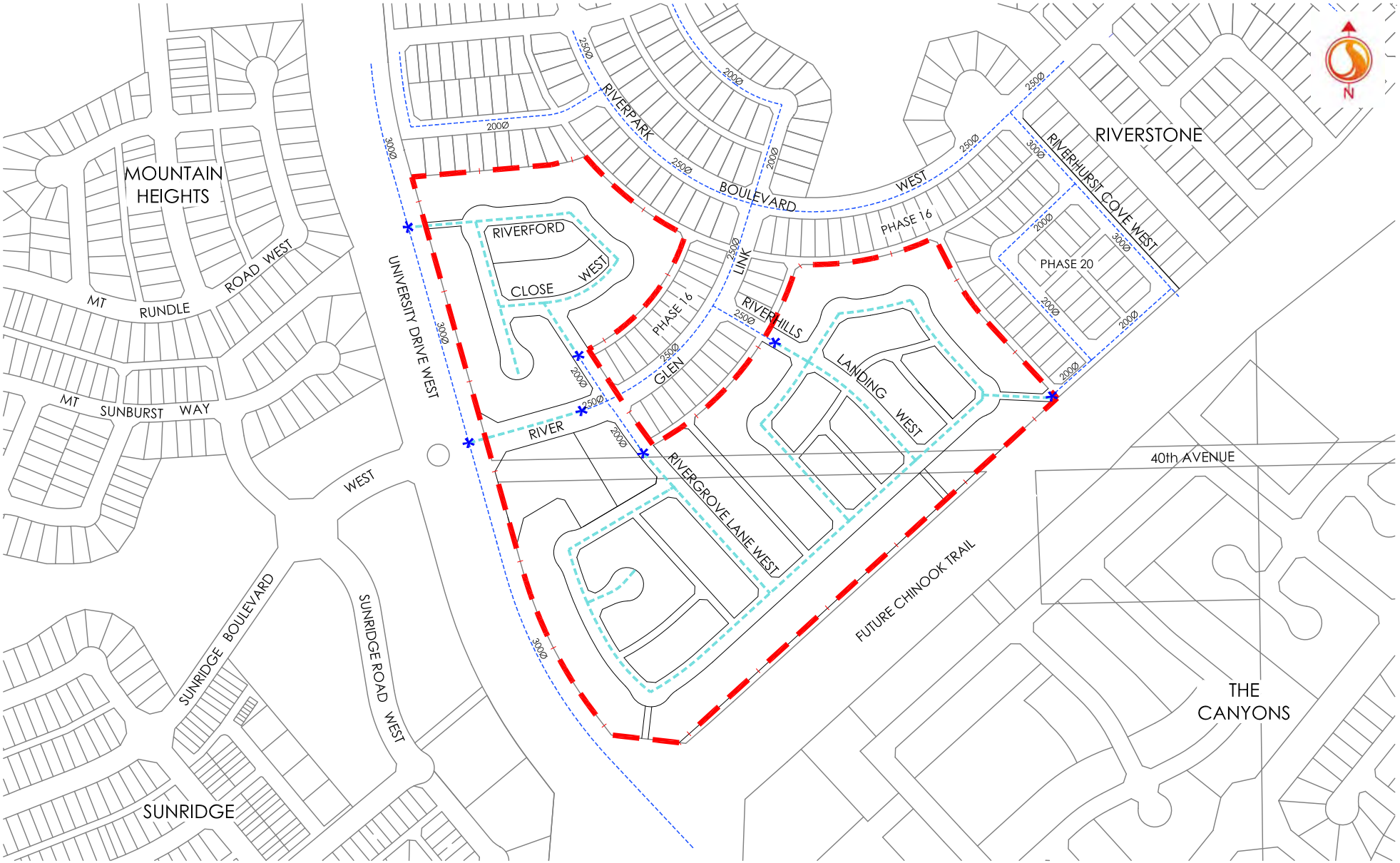

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Legend

- RiverStone OLP Adjustment Boundary
- Proposed Water Distribution (Ø 200)
- Existing Water Distribution (Ø Varies)
- * Connection to Existing / Water Line

RIVERSTONE OLP AMENDMENT | FIGURE 4.0

Water Distribution

and Connection Points

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5.0 SANITARY SEWER COLLECTION SYSTEM

A sanitary sewer collection system has been outlined on **Figure 5.0 Sanitary Sewer and Connection Points** along with key connection points. All servicing laterals will connect to the existing 250mm and 300mm Sanitary Sewer installed in River Glen Link. The estimated peak sewage flow from the OLP Amendment Area is 18L/s.

6.0 STORM WATER MANAGEMENT

Key to this Outline Plan Amendment in RiverStone is the development of a new storm water management facility at the intersection of University Drive and River Glen Link. The creation of this facility will ultimately service and attenuate approximately 11 Ha of urban drainage. Historically, RiverStone has managed its storm water run-off through a series of trapped lows controlled with Inlet Controls Devices (ICD) at each catch basin that limits flows to the SunRidge / RiverStone Storm Trunk to 51 L/s/ha. The OLP amendment area moves away from this model partially. A majority of the area identified as Phase 21 will continue to manage storm water through the installation of ICD's and creation of trapped low storage. Storm water run-off from Phases 17, 22 and a portion of Phase 16 (existing) will be drained without ICD's to the proposed River Glen dry pond facility. The development of this revised storm water management strategy has been developed from two key documents previously approved by the City of Lethbridge:

- RiverStone Storm Water Master Drainage Plan (1999) Stantec Consulting Ltd.
- Design Memo: RiverStone Phase 16-22 Overland Drainage and Grading (July 2009) Stantec Consulting Ltd.

To assess the effect of the proposed changes to drainage characteristics, we have reviewed all detailed design/as-built information of the trapped low system downstream of the OLP Amendment area up to the LNID Canal.

6.1 REVISIONS TO OVERLAND DRAINAGE CATCHMENTS

Overland drainage within the OLP Amendment area includes Phases 2, 16 and 20 (Existing) and Phases 17, 21 and 22 (Proposed).

Figure 6.1 Overland Drainage Catchments, Current and Proposed compares the original drainage boundary (Zone A that was to be controlled through trapped low storage) to the proposed drainage boundary (Zone C that will continue to be controlled through trapped low storage). In addition, Stantec has compared the overall storage requirement that was originally proposed and the new storage requirement based upon the development of a dry pond for Zone B. As can be seen graphically, existing and future trapped low storage volumes will be managed within the existing trapped lows along key overland flow routes.

Overland Drainage from Phases 17, 22 and portions of Phases 16 and 21 will be directed to the future dry pond as outlined in **Figure 6.1 Overland Drainage Catchments, Current and Proposed**.

Zones D and E which are adjacent to arterial roads are the two exceptions to the management plan described above. Zone D (0.10 ha) in the northwest corner of the plan will drain to University Drive and flow north to existing storm water management facilities at the intersection of University Drive and Grand River Boulevard. Zone E (1.04 ha) along the future Chinook Trail will drain to the arterial R/W. Drainage from this zone will need to be managed at an interim level during the design and construction of Phases 21 and 22. Ultimately, the design of Chinook Trail will need to accommodate drainage from the back of lots identified in Zone E.

6.2 MINOR STORM SEWER SYSTEM AND STORM TRUNKLINE

The existing storm trunk line installed in River Glen Link has been designed to accept storm water run-off at a rate of 51 L/s/ha and our new plan for this area will continue to discharge to this trunk line at that rate. The total allowable rate of discharge from Zones B and C will be limited to 1240 L/s; it is recommended that the future designs of Phases 17, 21 and 22 review total release rates from Phases 2, 16 and 20 prior to the finalization of detailed designs as the rebalancing of release rates from sub-catchments within Phases 17, 21 and 22 may provide opportunities for the reduction of trapped low storage.

Figure 6.2 Minor Storm System Proposed identifies the alterations that will be required to existing storm pipes and the conceptual routing of future storm lines.

Pipes upstream of the proposed dry pond (Zone B) will be designed to a 1:5 year rainfall event without the use of ICD's in catch basins. The dry pond will provide detention storage from the contributing areas and discharge to the River Glen trunk line. Phase 21 in Zone C will be designed using ICD's to attenuate flows to the trunk line.

It is recommended that the rebalancing of subcatchment release rates be considered during future detailed design to reduce the volume of trapped low storage in public Rights of Way. Specifically, the proposed drypond in Zone B should be designed with an outflow restriction that is less than 51L/s/ha to allow for an increased release rate from Phase 21 in Zone C thereby reducing the volume of trapped low storage. The corresponding increase in storage to the Zone B drypond can be easily accommodated within the PUL footprint and assist with reducing impacts to residential properties. The combination of varying release rates from Zones B and C shall not exceed 51 L/s/ha over the entire catchment area.

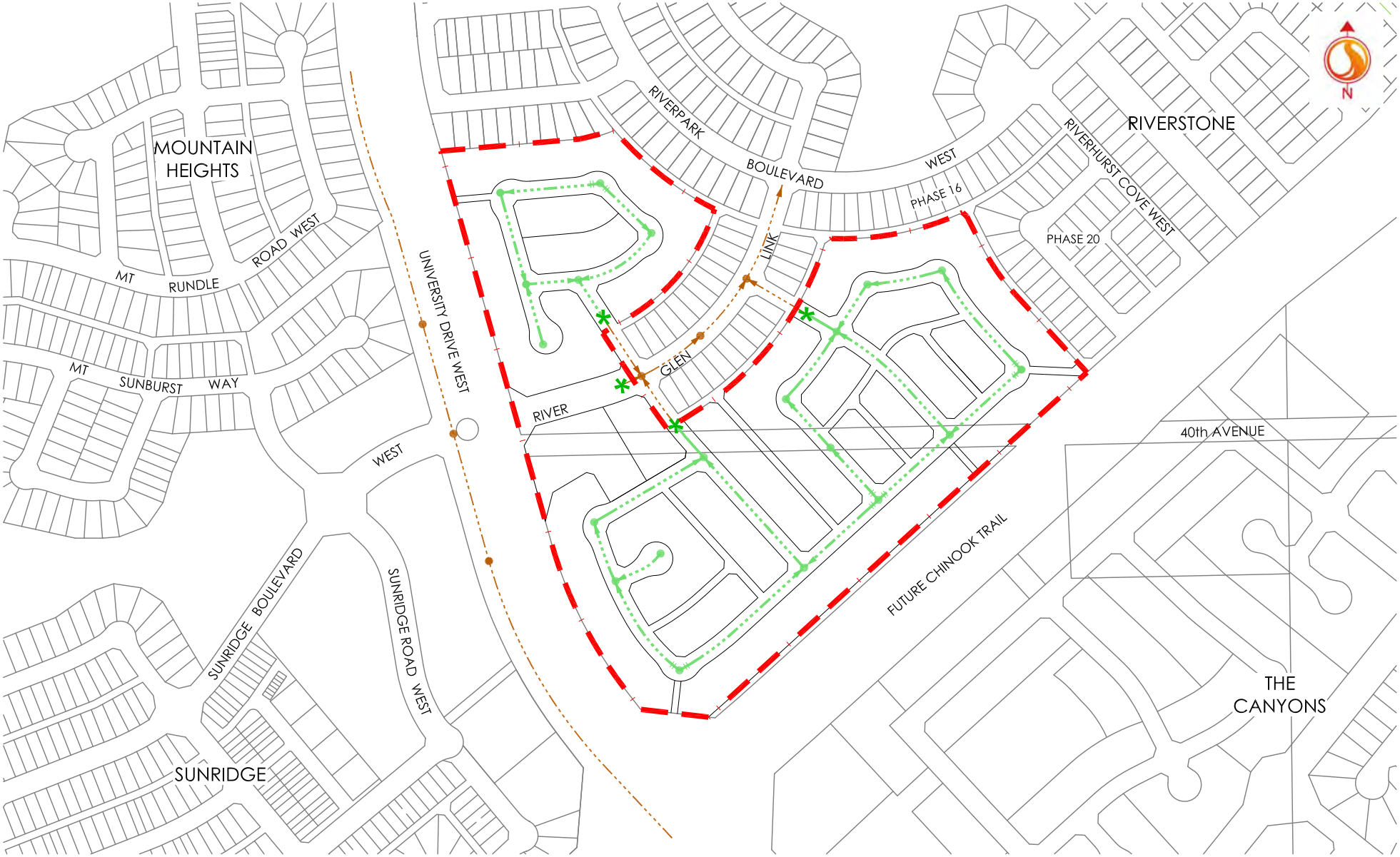
A foundation drain system will be installed and we anticipate that foundation drainage will be pumped from residences to the storm sewer system as is common practice in Lethbridge.

6.3 MAJOR STORM SYSTEM

During detailed design, major storm systems will designed to attenuate the storm water run-off from a 1:100 year rainfall event. This will be achieved within the amendment area through the development of a dry pond facility and, in the case of Phase 21, trapped low storage.

Stantec has reviewed the possibility of connecting the existing University Drive Facility adjacent to RiverStone to the proposed Zone B facility. Given the projected vertical design of the internal pipe system within RiverStone, Stantec is proposing to keep the two facilities separate except for the connection of an emergency overland flow route from University Drive to the proposed RiverStone Facility. The University Drive control structure will remain in place and a new control structure will be installed for the proposed RiverStone dry pond.

Figure 6.3 Major Storm System Overland Flow Routes identifies key drainage patterns, overland flow routes and conceptual trapped low locations.



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Legend

- RiverStone OLP Amendment Boundary
- Proposed Sewer Trunk
- Existing Sewer Trunk
- * Connection to Existing Sewer Trunk

RIVERSTONE OLP AMENDMENT | FIGURE 5.0

Sanitary Sewer

and Connection Points

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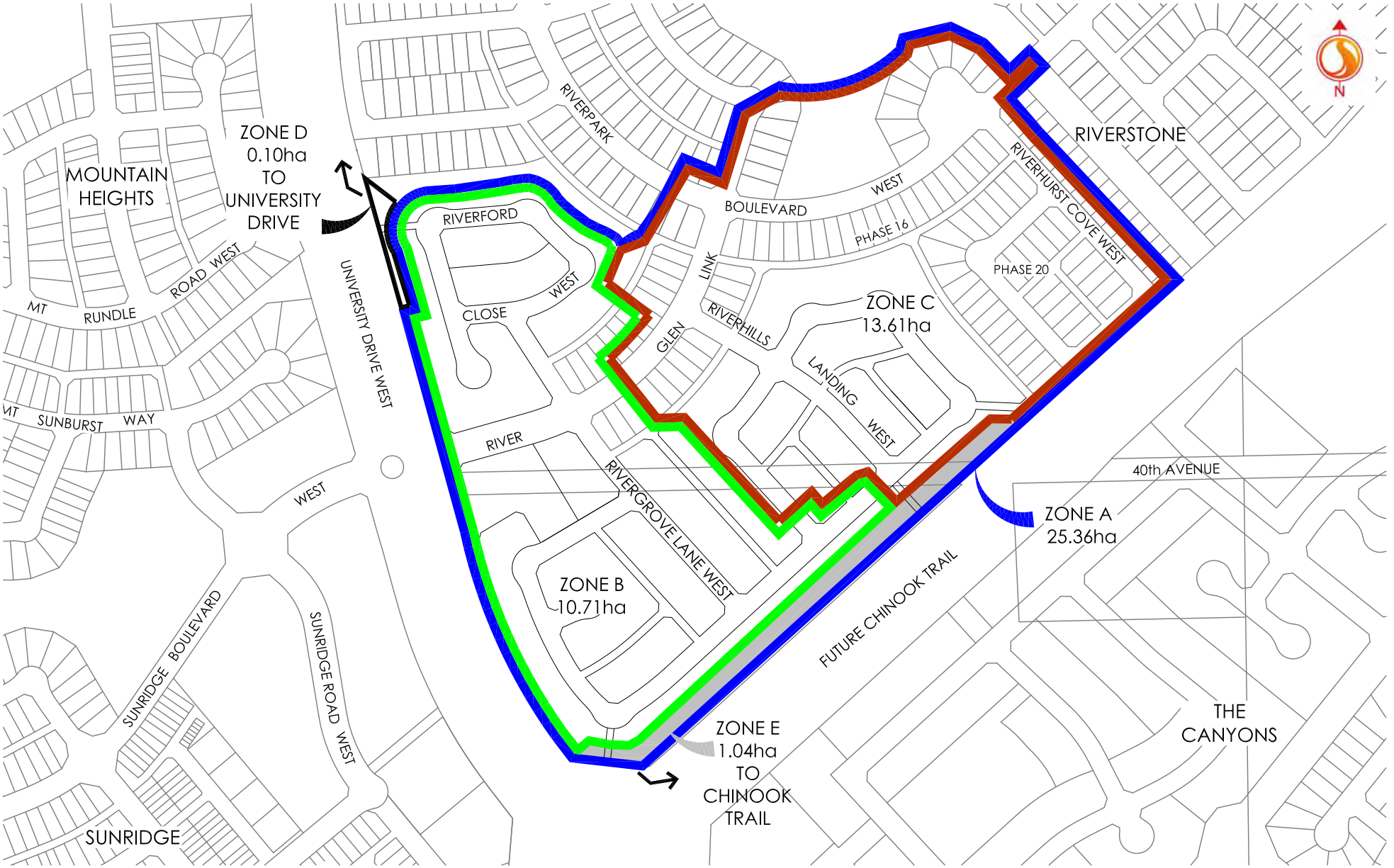

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Legend

- Original Overland Drainage Boundary ~ Zone A
- Proposed Drypond Overland Drainage Boundary ~ Zone B
- Proposed Trapped Low Overland Drainage Boundary ~ Zone C
- Proposed Overland Drainage to University Drive ~ Zone D
- Proposed Overland Drainage to Chinook Trail ~ Zone E

RIVERSTONE OLP AMENDMENT | FIGURE 6.1

Overland Drainage Catchments

Current & Proposed

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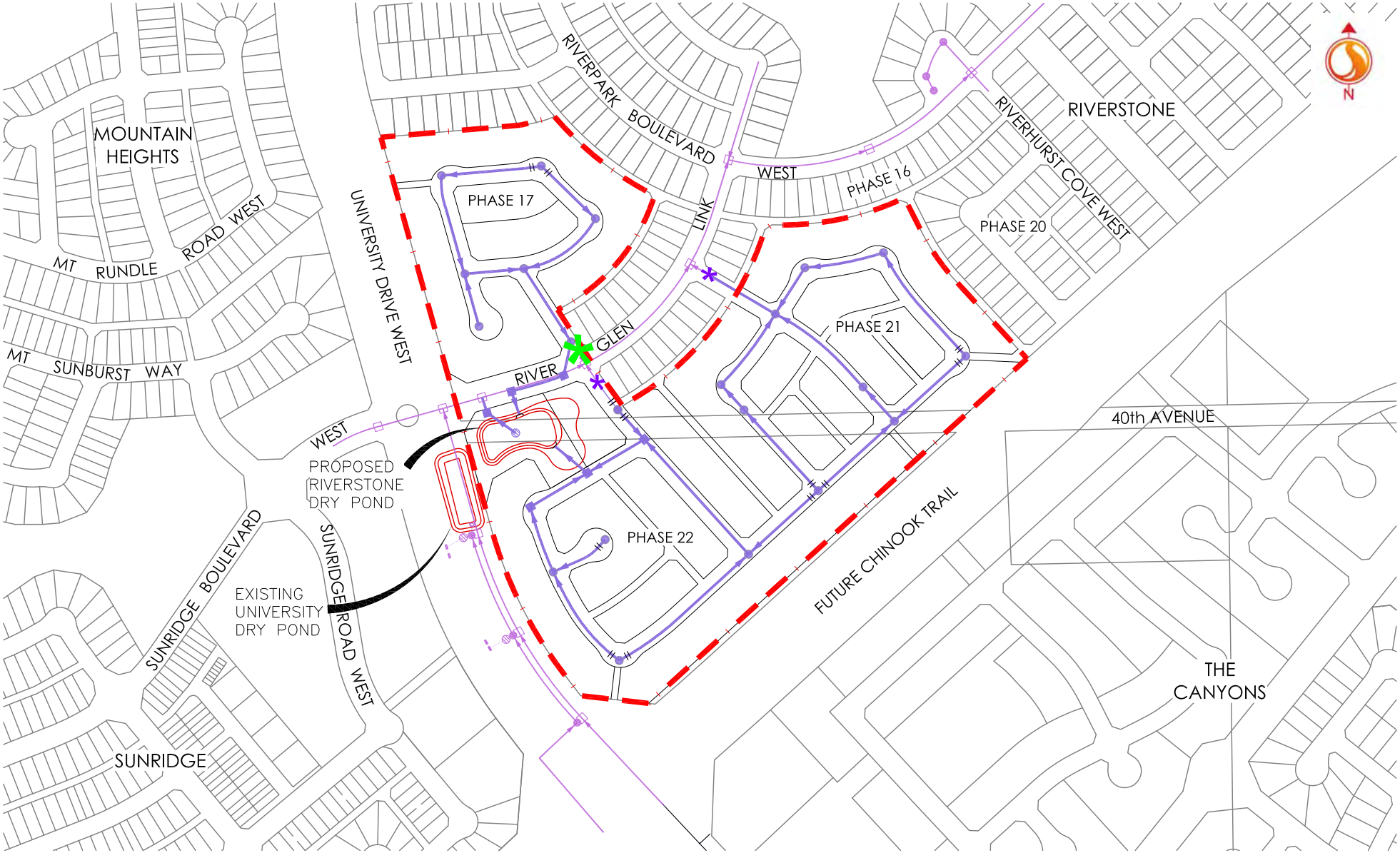

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May 23, 2014

Legend

- RiverStone OLP Amendment Boundary
- Proposed Storm Line
- Existing Storm Trunk
- Connection to Existing Storm Trunk
- Existing Phase 17 Storm Trunk Lateral to be Abandoned

RIVERSTONE OLP AMENDMENT | FIGURE 6.2

Minor Storm System

Proposed

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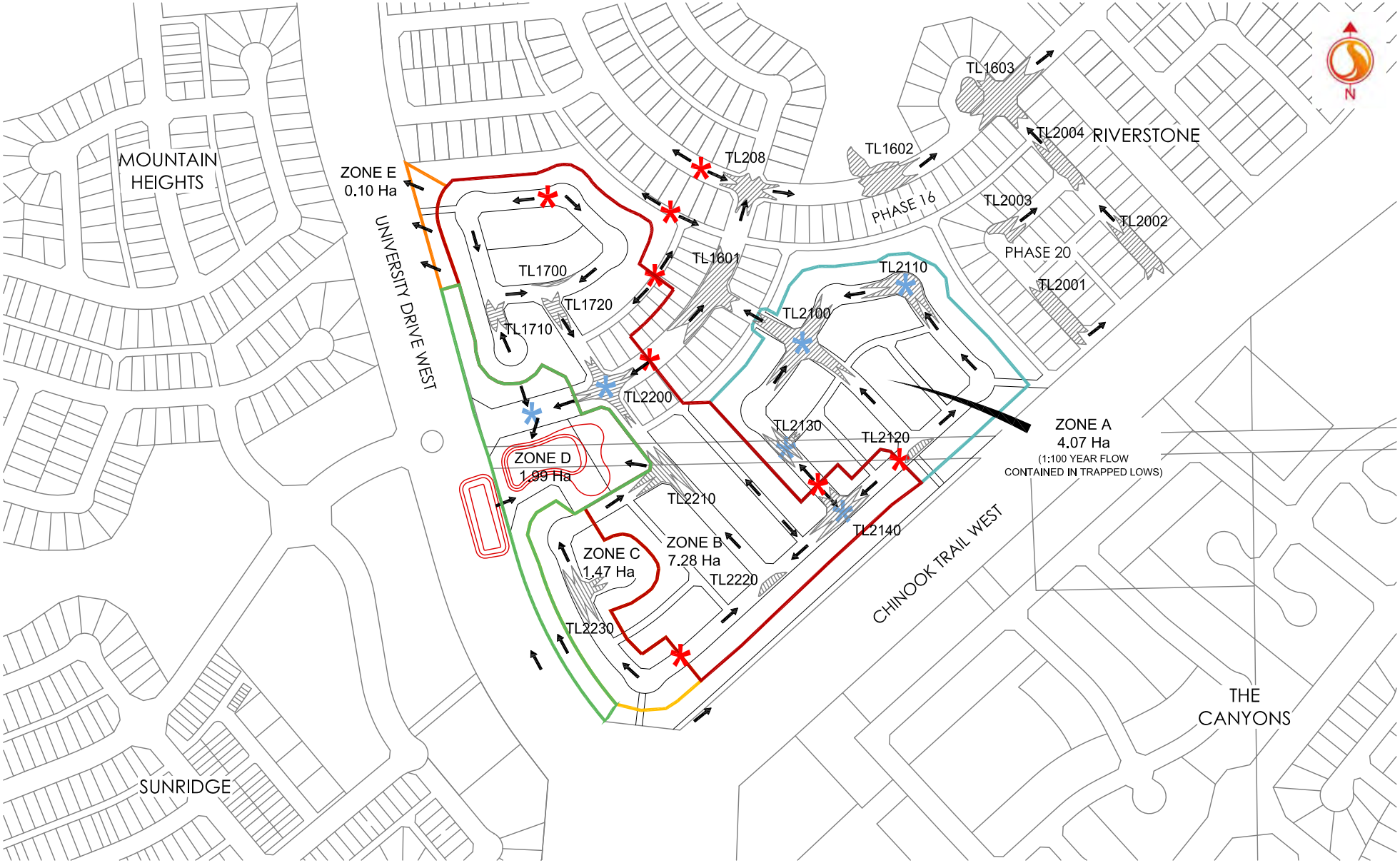

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Legend

- Overland Flow Direction
- High Point
- Low Point
- Trapped Lows

RIVERSTONE OLP AMENDMENT | FIGURE 6.3

Major Storm System

Overland Flow Routes

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7.0 OPEN SPACE NETWORK

RiverStone was established with an Award Winning Community Vision in 2002 and as intended this open space network is to seamlessly weave throughout all corners of the Community. Identity and character is vital to establishing a sense of place and community pride. People who reside in RiverStone are proud of their Community's brand and Phases 17, 21 and 22 will maintain this quality.

RiverGlen Link will function as RiverStone's third Community Entrance featuring tree lined boulevards that also provide pedestrian sidewalk connections to and from University Drive. RiverStone Community Signage will be located on the Northeast and Southeast Corner of the intersection of RiverGlen Link and University Drive. This Entry Feature will complement the existing established community way finding treatments currently found on Grand River Boulevard and RiverStone Boulevard. The Entry Feature will continue to feature the signature natural river rock Cairns found throughout the Community.

The Storm Water Management Facility will have similar Dry Pond Landscape Treatment as found in RiverStone's Phase 7 Dry Pond. Dryland Grass will transition to the arterial road landscape treatment; irrigated trees will be planted throughout the perimeter of the Pond along with Pathway connections to RiverGrove Lane.

A dog park is envisioned for the 0.30 ha parcel adjacent to the proposed storm water management facility. During detailed design, the following guidelines should be considered:

- A staging area (double gates) – prevents dogs from escaping
- Trees and landscaping provide shade and comfort
- Natural hills and mounts to compliment the equipment
- A water supply for dogs (doggy fountains)
- Seating for dog owners
- Trash cans

The site has been separated from residential land uses and buffering of residential from the dog park should be considered at detailed design.

Roads adjacent to the park will be designed to accommodate on-street parking. Given the size of the park area, onsite parking should not be required and would take up useable park space.

The exterior boundaries of Phases 17, 21 and 22 will continue with the unique perimeter natural river rock clad pillars and cedar fencing. The South corner of Phase 22 will provide a pedestrian connection to the arterial intersection of University Drive and the future Chinook Trail, Regional Pathways and adjacent Communities.

8.0 CONCLUSION

To conclude, the revisions as outlined within this document have many positive impacts to the surrounding RiverStone Development.

Most notably, the creation of a storm water management facility will remove the need for trapped low storage in public road rights of way for a portion of the amendment area, and reduce the impact of overland flows along RiverGlen Link and RiverPark Boulevard. The removal and relocation of local roads running parallel to the Chinook Trail R/W have made the development more efficient in terms of initial capital construction costs and long term maintenance costs.

Overall population and unit densities have been reduced from the original plan and the development will have no negative impact on the infrastructure that has already been installed.

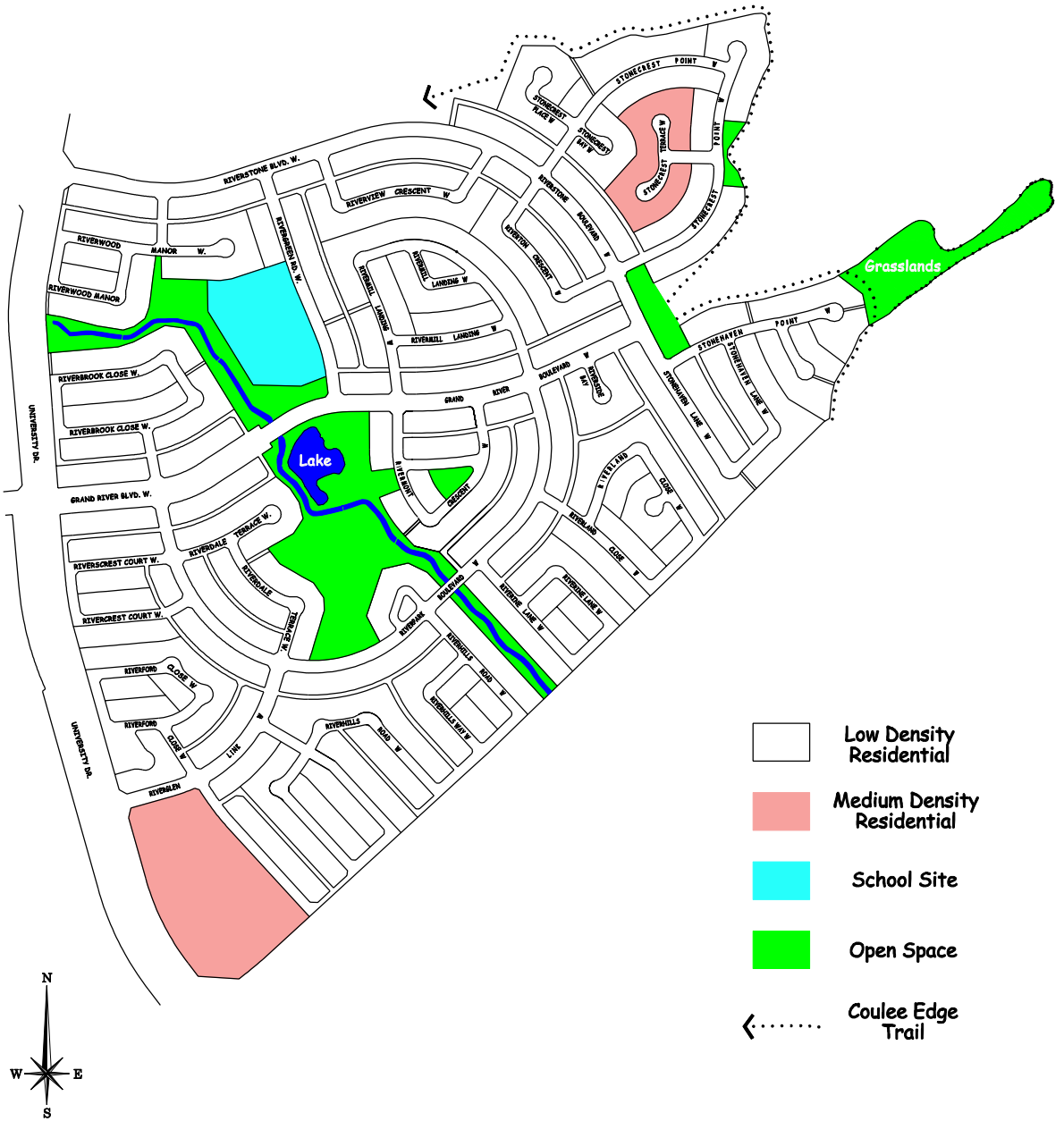
Open Space Development and Community Entrance Roads will utilize theming, features and materials consistent with previous open space development and community entrance roads. In addition, the inclusion of a dog park along RiverGlen Link will provide a new opportunity for the residents of RiverStone.

APPENDIX A

RIVERSTONE OUTLINE PLAN AND CITY OF LETHBRIDGE LAND USE DISTRICT MAP

RiverStone Outline Plan

Outline Plan Approved by M.P.C. September 14, 1999
Outline Plan Amended by M.P.C. September 3, 2003



CITY OF

Lethbridge

LAND USE DISTRICTS MAP

AMENDMENTS TO SEPTEMBER 3, 2013

C-D	Downtown Commercial	
C-G	General Commercial	
C-H	Highway Commercial	
C-L	Local Commercial	
C-N	Neighbourhood Commercial	
C-S	Shopping Mall Commercial	
DC	Direct Control	
I-B	Industrial Business	
I-G	General Industrial	
I-H	Heavy Industrial	
P-B	Public Building	
P-R	Parks and Recreation	
P-SO	Specialist Office	
P-T	Public Transportation	

R-L	Low Density Residential	
R-Lb	Low Density Residential	
R-Lz	Low Density Residential	
R-CL	Comprehensively Planned Low Density Residential	
R-CM	Comprehensively Planned Medium Density Residential	
R-CM-20	Comprehensively Planned Medium Density Residential	
R-M	Mixed Density Residential	
R-MH	Mobile Home	
R-RL	Restricted Low Density Residential	
R-SL	Small Parcel Low Density Residential	
R-37	Medium Density Residential	
R-37L	London Road Neighbourhood Higher Density	
R-50	Medium Density Residential	
R-60	Medium Density Residential	
R-75	Medium Density Residential	
R-100	High Density Residential	
R-150	High Density Residential	
R-200	High Density Residential	
U-I	Urban Innovation	
FUD	Future Urban Development	
V	Valley	

UNOFFICIAL MAP - CONSOLIDATED FOR CONVENIENCE ONLY. FOR ZONING OF INDIVIDUAL PROPERTIES CONTACT DEVELOPMENT SERVICES DEPARTMENT.

APPENDIX B

DRC AMENDMENT EXPECTATIONS

CITY OF
Lethbridge

January 22, 2013

Brad Schmidtke, C.E.T.
Urban Land Engineering Team Lead
Stantec Engineering
Lethbridge, AB

Dear Brad:

RE: Proposed Riverstone Outline Plan amendment
Development Review Committee Comments

Please be advised that the Development Review Committee (DRC) has reviewed and discussed your proposal for an amendment to the Riverstone Outline Plan and has the following expectations for the amendment submission:

1. An outline plan amendment summary which identifies proposed land use changes, includes land use statistics and a section that evaluates the proposal and identifies any corresponding impacts to the entire plan area.
2. Include figures showing the new road network and contemplated land uses and transit route options.
3. Geotechnical Report – soil stability
4. Storm Water Management Design with figures showing overland flows and trapped lows, sanitary sewer and water main layout with connection points.

Upon sign off of the submission by the DRC, a formal application is required for submission to the appropriate approval authority. I would estimate 5 to 6 weeks for the submission review process and 5 to 6 weeks for the formal approval process.

Sincerely,

Barry Peat,
Chair, Development Review Committee
City of Lethbridge

cc. RELD Manager

PLANNING AND DEVELOPMENT SERVICES DEPARTMENT
Phone: 403-320-3927 • Fax: 403-327-6571 • E-Mail: barry.peat@lethbridge.ca

APPENDIX C

GEOTECHNICAL REPORT

GEOTECHNICAL INVESTIGATION
RESIDENTIAL SUBDIVISION
RIVERSTONE PHASES 17, 21 & 22
LETHBRIDGE, AB

Submitted To:
Stantec Consulting Ltd.
220 – 4th Street South, Suite 290
Lethbridge, Alberta T1J 4J7

Submitted By:

AMEC Environment & Infrastructure,
a division of AMEC Americas Limited
469 – 40 Street South
Lethbridge, Alberta
T1J 4M1

June, 2012

AMEC File: BX30201

TABLE OF CONTENTS

1. INTRODUCTION

1.1. General

At the request of Stantec Consulting Ltd. (Stantec), AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC), has carried out a geotechnical investigation to support the proposed residential development of Phases 17, 21 and 22 of Riverstone Subdivision in Lethbridge, Alberta.

This report summarizes the results of the site reconnaissance, field work and laboratory testing, and provides geotechnical discussion and recommendations to support the design and construction of the proposed development.

1.2. Terms of Reference

The scope of work for the current investigation was outlined in AMEC's proposal PR11-095 dated November 18, 2011. Written authorization to proceed with the evaluation dated February 2, 2012 was received from Mr. Brad Schmitdke, C.E.T. of Stantec.

Based on information obtained during site reconnaissance and test hole programs, AMEC has provided engineering guidelines for the geotechnical design and construction of residential development in the study area.

This report is provided on the basis of the terms of reference presented above, and on the assumption that the design will be in accordance with applicable codes and standards. If there are any changes in the design features relevant to the geotechnical analyses, or if any questions arise concerning geotechnical aspects of the codes and standards, this office should be contacted to review the design.

The information in this report in no way reflects on the environmental aspects of the soil. If additional information in this regard is required, AMEC can provide that upon request.

2. METHODOLOGY

In order to assess the subsurface soil and groundwater conditions at the site, AMEC visited the site on May 1, 2012 and monitored the advancement of a series of ten widely spaced boreholes within the study area. The boreholes were advanced at the locations denoted on Figure 1 as boreholes BH12-01 to BH12-10, inclusive.

The boreholes were advanced using a truck-mounted drill equipped with continuous flight solid stem augers, and were terminated at depths ranging between about 6.1 m and 6.6 m below existing grades.

During the drilling, disturbed soil samples were collected from the auger flights. In addition, Standard Penetration Tests (SPTs) were also carried out at regular intervals to assess the soil consistency/compactness, and obtain representative samples for identification.

Upon completion of the drilling, 25 mm diameter standpipes (hand-slotted) were inserted into select boreholes. The annular space around the standpipe was backfilled with the auger cuttings, and a bentonite cap was installed at the surface. The remaining boreholes were backfilled with the drill cuttings.

The drilling was carried out under the technical supervision of an AMEC technician, who collected the soil samples and logged the subsurface conditions. The recovered soil samples were transported to AMEC's Lethbridge laboratory for further review by a geotechnical engineer, and selected laboratory classification testing. Laboratory testing for this project consisted of soil moisture content determinations and Atterberg limits testing, with results presented on the borehole logs (Appendix A).

Samples remaining will be stored for a period of three months following this report, at which time they will be discarded unless we are requested otherwise by the Client.

3. SITE AND SUBSURFACE CONDITIONS

3.1. Site Description

The subject study encompasses an area of land near the southwest extent of the existing Riverstone subdivision development. At the time of AMEC's investigation, the site was generally vacant, with the exception of the current alignment of 40 Avenue West, which traverses through about the centre of the study area from east to west. It is also noted that large diameter storm sewer pipes are already present along the proposed alignment of Riverglen Link along the south side of proposed Phase 17.

In general, the subject site is relatively flat, with increasing local relief toward the south. Ground surface elevations generally tend to decrease toward the east.

3.2. Surficial and Bedrock Geology

Based on quaternary mapping for the area[1], the subject area is characterized by stagnation moraine, including till of uneven thicknesses up to about 30 metres thick, local water sorted material, and hummocky topography with local relief to up to 15 metres.

Based on bedrock geology mapping[2], the overburden deposits in the study area are generally underlain by pale grey continental sedimentary bedrock (Oldman Formation) of the Mesozoic Era.

3.3. Soil Stratigraphy

The subsurface conditions encountered in the boreholes were generally consistent with the published geology and the geotechnical information reviewed for the subject and surrounding area. The detailed stratigraphy encountered in the boreholes is described on the appended borehole logs, and summarized in the following paragraphs. It must be noted that boundaries of soil indicated on the borehole logs are inferred from non-continuous sampling and observations during excavation. These boundaries are intended to reflect transition zones for the purposes of geotechnical design, and should not be interpreted as exact planes of geological change.

3.3.1 Topsoil and Fill

The boreholes were each surfaced with a layer of topsoil. The topsoil, ranging between about 150 mm and 200 mm thick, was generally described as silty loam with rootlets, dark brown and moist.

---

[1] Shetson, I (1987) *Quaternary Geology, Southern Alberta*. Alberta Research Council, Natural Resources Division.

[2] Jackson, P.C. (1981) *Geological Highway Map of Alberta.* The Canadian Society of Petroleum Geologists.

Some minor existing clay fill was also noted at boreholes BH12-06 and BH12-07. The clay fill was generally described as medium plastic, silty, sandy, brown, stiff and moist, and extended to depths of about 0.75 m below existing grades at the two boreholes.

The presence of additional fill, or organics, should be anticipated in conjunction with the presence of 40 Avenue West, which traverses the site.

3.3.2 Clay Till

The predominant natural mineral soil encountered beneath topsoil and fill was clay till. The clay till was generally described as medium plastic, brown, contained little sand, trace gravel, occasional trace coal fragments and oxide inclusions. SPT N-values ranged between about 7 and 16 blows per 300 mm of sampler penetration, indicating a firm to stiff consistency. Based on laboratory testing, the *in situ* water content of the clay ranged between 12 percent and 40 percent, generally indicative of damp to very moist soil conditions.

A series of three representative samples of the clay were subjected to Atterberg limits testing; results are presented on the Borehole Logs. Based on the results of the Atterberg limits testing, the clay is generally of medium plasticity.

3.4. Groundwater Conditions

As noted in the previous Section 2, standpipes were installed within four selected boreholes to facilitate observations of the depth to the stabilized groundwater table. The standpipes were monitored on May 7, 2012 (about a week following the drilling), at which time the following groundwater depths were recorded:

Borehole No.	GW Depth (m)
BH12-01	0.29
BH12-05	--
BH12-08	4.02
BH12-10	--

It is noted that borehole BH12-01 was located in a low area, and the shallow groundwater water depth at this location may reflect localized near-surface water accumulation rather than the depth to the regional groundwater table in the area.

It is further noted that the groundwater conditions are expected to fluctuate seasonally in response to spring thaw and periods of heavy precipitation. Capillary rise effects should also be anticipated within fine-grained soil deposits.

4. GEOTECHNICAL DISCUSSION & RECOMMENDATIONS

4.1. General

Based on information provided by Stantec, it is understood that the City of Lethbridge is proposing the development of Phases 17, 21 and 22 of Riverstone Subdisvision. The proposed development will generally be characterized by single family residences, with asphalt paved street and back alleys, and full municipal servicing.

In general, the subject area assessed will support the conventional design and construction of the proposed residential development.

Based on the results of the current investigation and our understanding of the proposed development, the following sections provide geotechnical discussion and recommendations pertaining to site preparation, site grading, excavations and dewatering, conventional strip and spread footing foundations, basements, slabs, drainage and backfill, pavement construction, concrete mix considerations, and seismic design considerations.

4.2. Site Preparation, Excavation, Grading and Dewatering

Prior to placement of any fill or concrete, site stripping will be required. As indicated in the previous Section 3.3, topsoil thicknesses (A Horizon) ranged between about 150 mm and 200 mm at the borehole locations assessed. Typically, the underlying B Horizon material (inorganic, but organic stained) can remain in place or be incorporated into fill materials, depending upon the extent of organic influence. Some existing fill, to about 0.75 m depth was also encountered, and also should be removed as part of the site stripping.

It is noted that thicker areas of organic soils should be anticipated in low/wet areas not assessed as part of this report. The presence of extensive fill should also be anticipated along the alignment of 40 Avenue West, which will also require removal and subgrade reconstruction.

All excavations should conform to Part 32 of the 2009 Alberta Occupational Health and Safety Code.

The material used for engineered fill that will support footings, slabs or roadways should comprise of imported granular or other approved material. In this regard, the majority of the onsite clay materials are generally considered acceptable for use as engineered fill, provided the material is free of organics and/or otherwise deleterious materials and at a moisture content within about optimum and three percent above optimum (as determined by standard Proctor testing). Engineered fill should be placed in maximum 200 mm thick lifts, moisture conditioned as required and uniformly compacted to 98 percent of Standard Proctor Maximum Dry Density (SPMDD). Where fill thicker than a metre is present in proposed building areas, the structural fill below anticipated foundation elevations should be compacted to a minimum of 100 percent of SPMDD. Any engineered fill should also extend laterally beyond the edges of foundation elements a minimum distance equal to the thickness of fill beneath the foundation or slab. *In situ* compaction testing should be carried out during the fill placement to ensure that the specified compaction is being achieved.

As noted on the borehole logs, groundwater seepage observed during the drilling was generally limited to minor seepage from localized sand lenses encountered within the clay till stratum. Accordingly, only minor groundwater accumulations within service trench excavations are anticipated from localized saturated sand pockets encapsulated within less permeable clay till deposits. More extensive groundwater infiltration should be anticipated within low areas, such as in the area of borehole BH12-01. It is anticipated that the infiltrating groundwater, where encountered, can be accommodated by conventional sump pumping techniques.

Site grading, both during and following construction, should be provided such that surface runoff is rapidly shed from building and roadway areas to a positive drainage system. Water should not be allowed to pond on or adjacent to building and roadway areas. A minimum grade of two percent is recommended to accommodate surface runoff and to minimize the potential of saturation and degradation of the subgrade.

4.3. Service Trench Excavation, Pipe Bedding and Trench Backfill

As indicated previously, all excavations should conform to Part 32 of the 2009 Alberta Occupational Health and Safety Code.

For protection against frost action, service pipes should have at least 2.1 m of soil cover. Alternatively, insulation can be used to reduce the thickness of soil cover required. AMEC can provide further recommendations in this regard, upon request.

Bedding for services should be provided in accordance with City of Lethbridge specifications.

In general, it is anticipated that the majority of native soils excavated from the service trenches would be suitable for re-use as trench backfill, provided the work is carried out during relatively dry weather. Any excavated soils proposed for re-use as backfill should be examined by a geotechnical engineer. For clay backfill, the material should be within about optimum and three percent above optimum for best compaction results. In this regard some moisture conditioning (i.e., drying) should be anticipated.

Backfill should typically be compacted to a minimum of 95 percent of SPMDD in non-structural (i.e., landscaped) areas. Where backfill will support pavement or foundations, backfill should typically be compacted to a minimum of 98 percent and 100 percent, respectively, of SPMDD.

4.4. Curbs and Sidewalks

The concrete for the curbs and gutters should be proportioned, mixed, placed and cured in accordance with City of Lethbridge specifications.

During cold weather, any freshly placed concrete should be covered with insulating blankets, or be hoarded and heated, to protect against freezing.

The subgrade for the sidewalks should comprise of undisturbed native soil or well-compacted fill. A minimum 150 mm thick layer of compacted (minimum 98 percent SPMDD) granular

material meeting the City of Lethbridge gradation specification for Granular Base Course (GBC). should be placed below the sidewalk slabs.

4.5. Pavement Construction

Prior to placement of granular fill for asphalt base, areas to be paved should be stripped of all topsoil, organics and/or other otherwise deleterious material, as outlined in the previous Section 4.2. The exposed subgrade must then be thoroughly proof-rolled. Any soft spots revealed by this or any other observations must be over-excavated and backfilled with approved material.

Following the stripping, as outlined above, the exposed subgrade should be scarified to a minimum depth of 300 mm, and compacted to a minimum of 98 percent of SPMDD at a moisture content within about optimum and three percent above optimum for clay materials.

If weaker zones are identified, some localized subexcavation and replacement with clean fill may also be required; however, this work should be based on site direction by a geotechnical engineer at the time of construction.

Should any instability occur under compaction equipment, or other construction equipment, the operation should cease and the geotechnical engineer should be asked to review the situation.

Provided the preceding recommendations are followed, the pavement thickness design requirements given in the following table are recommended based on the anticipated traffic loading and subgrade conditions.

Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Lanes	Local Residential Streets	Residential Collector Streets
Asphaltic Concrete	97% Marshall Density	75 mm Type III*	75 mm Type III*	60 mm Type I* 60 mm Type II*
Granular Base Course*	100% SPMDD*	200 mm	200 mm	100 mm
Granular Subbase Course	100% SPMDD*	--	--	150 mm
Subgrade Preparation	98% SPMDD	150 mm	300 mm	300 mm

*Notes: 1) City of Lethbridge Specification
2) SPMDD denotes Standard Proctor Maximum Dry Density.

The recommended pavement structure provided in the above table is based on the natural subgrade soil properties determined from visual examination and textural classification of the soil samples. Consequently, the recommended pavement structures should be considered for preliminary design purposes only, and should be verified during construction based on actual site subgrade conditions.

If construction is undertaken under adverse weather conditions (i.e., wet or freezing conditions) subgrade preparation and granular base requirements should be reviewed by the geotechnical engineer. As well, if only a portion of the pavement will be in place during construction, the granular base may have to be thickened, and/or the subgrade improved with a geotextile separator.

Samples of both the granular base aggregates and asphaltic concrete paving materials should be checked for conformance to the City of Lethbridge specifications prior to utilization at the site, and during construction.

Good drainage provisions will optimize pavement performance. The pavement subgrade and the finished pavement surface should be free of depressions and should be sloped (preferably at a minimum grade of two percent) to provide effective surface drainage toward catchbasins. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas.

A program of *in situ* density testing must be carried out to verify that satisfactory levels of compaction are being achieved.

4.6. Residential Construction – Preliminary Comments

For preliminary design purposes, the following preliminary general discussion and recommendations are offered to support the design and construction of residences within the study area site. Specific, detailed geotechnical investigations are required for non-residential developments in the subdivision, and may be needed for some residential structures if there are unusual design features associated with the residence.

4.6.1 Conventional Strip and Spread Footing Foundations

Based on AMECs review of the soil conditions within the widely spaced boreholes at the site, the stiff natural occurring clay till encountered within the boreholes is generally considered suitable for the support of conventional strip and spread footings for proposed single family residences. For preliminary design, a Serviceability Limit States (SLS) bearing pressure of 75 kPa is recommended, with a corresponding unfactored Ultimate Limit States (ULS) bearing pressure of 225 kPa. A geotechnical resistance factor of 0.5 should be applied to the ULS bearing pressure, per current building code requirements.

As indicated above, further investigation and/or review of the bearing soils associated with any non-residential structures will be required to support detailed design of the various proposed structures.

For protection against frost action, perimeter footings in heated areas should be extended to provide at least 1.5 m of soil cover. For any unheated buildings or portions of the building, footings should have at least 2.1 m of soil cover. Alternatively, insulation can be used to reduce the thickness of soil cover required.

4.6.2 Damp-Proofing and Drainage

It is noted that installation of weeping tile around residences is required by City of Lethbridge bylaw regardless of groundwater elevation. The requirements for weeping tile installation are outlined in Section 9.14 of the 2006 Alberta Building Code. Weeping tiles must discharge to either a gravity outlet, or to a pumped sump, in accordance with local regulatory requirements.

In conjunction with installation of weeping tile, below grade foundation walls around basements require damp proofing, in accordance with the 2006 Alberta Building Code.

Weeping tile flow due to surface water infiltration along foundation walls can be minimized by providing a modest amount of compaction to the exterior foundation wall backfill, thus minimizing future settlement of the backfill. The backfill within two metres of the residence foundation should be graded away from the foundation at approximately a ten percent slope. Downspout roof leaders should discharge onto splash pads at least a metre from the foundation walls.

Where basement elevations extend to within about a metre of the groundwater elevations observed as part of the current investigation, more extensive water proofing measures may be required in conjunction with the potential for higher post-development groundwater conditions.

4.6.3 Construction of Slabs-on-Grade

In general, it is anticipated that engineered fill or the natural clay till at the site will provide adequate support for grade supported basement floors, concrete garage slabs, driveways and parking slabs, provided the subgrade prepared as outlined in the previous Section 4.2.

Following preparation of the subgrade surface, a levelling course of 25 mm nominal size well-graded crushed gravel at least 150 mm in compacted thickness is recommended directly beneath the slabs. The gravel should be compacted to at least 98 percent of SPMDD.

For the basement floor slabs, a 150 mm minimum thickness of 25 mm crushed washed rock should be used instead of the well graded crushed gravel.

The excavated subgrade for the slabs on grade should be protected at all times from rain, snow, freezing temperatures, excessive drying and the ingress of free water. To minimize the potential negative effects of settlement or heave in soil below the slabs, it would be preferable to allow slabs to float with no rigid connections to walls or foundation elements except at doorways.

Some relative movement between the slabs-on-grade and adjacent walls or foundations and differential movements within the slabs should be anticipated. Where recommendations outlined in this report are followed, these movements are expected to be within tolerable limits.

4.7. Concrete Mix Considerations

In general, the natural mineral soil deposits in the Lethbridge area contain moderate to high levels of water soluble sulphates, indicating severe potential for sulphate attack on concrete in contact with native mineral soil deposits. Based on the CSA Standard A23.1-09 the Class of Exposure for concrete elements in contact with the clay soils is S-2. Accordingly, sulphate resisting cement (i.e., Type 50) should be used in the manufacture of concrete in contact with soil at this site. For durability purposes the concrete must have a maximum water to cementitious materials ratio of 0.45, and a minimum 56 day compressive strength of 32 MPa. Air entrainment and curing should follow CSA A23.1-09 Table 2 requirements

An air entrainment agent is recommended for concrete exposed to cyclic freeze-thaw action. In addition to the improved durability, the air entraining will provide improved workability of the plastic concrete.

4.8. Seismic Design Considerations

The 2006 Alberta Building Code has adopted the National Building Code (NBCC) requirements for Seismic Design Consideration. The earthquake/seismic design parameters should be reviewed by a Structural Engineer and incorporated into the design as required. Based on soil conditions observed during the geotechnical investigation and published information for the area, the subgrade soils are generally characterized as stiff soils over bedrock. In this regard, the site is classified as Class D, as shown in Table 4.1.8.4.A in the 2006 Alberta Building Code.

4.9. Testing and Inspection

The geotechnical engineering design recommendations presented in this report are based on the assumption that an adequate level of inspection and review will be provided during construction, and that all construction will be carried out by a suitably qualified contractor experienced in foundation and earthworks construction. An adequate level of inspection is considered to be:

- For earthworks: full time monitoring and compaction testing
- For concrete construction: testing of concrete supplier mixes for conformance with prescribed and/or performance concrete specifications
- For pavement construction testing of supplier materials and mixes for conformance with prescribed specifications

5. CLOSURE

The recommendations given in the above sections are based upon interpreted conditions found within the ten boreholes advanced at this site. Should subsurface conditions other than those presented in this report be encountered during construction, the Client should notify our office so that the recommendations can be reviewed.

Soil conditions, by their nature, can be highly variable across a construction site. The placement of fill and prior construction activities on a site can contribute to variable near surface soil conditions. A contingency amount should be included in the construction budget to allow for the possibility of variations in soil conditions, which may result in modification of the design, and/or changes in the construction procedures.

AMEC should be retained for a general review of the final design drawings and specifications to verify that this report has been properly interpreted and implemented. If not afforded the opportunity to conduct this review, AMEC will assume no responsibility for interpretation of the recommendations in this report. AMEC would be pleased to provide any further information that may be needed during design and to advise on the geotechnical aspects of specifications for inclusion in contract documents.

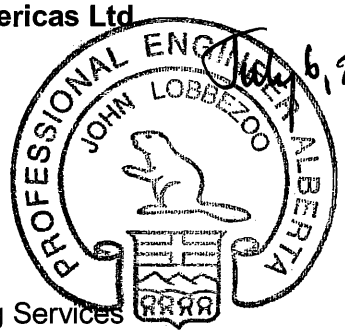
As noted herein, further investigation and/or review will be required to support the detailed design and construction of residential foundations.

This report has been prepared for the exclusive use of the Stantec and their designers for specific application to the development described in this report. Any use that a third party makes of this report, or any reliance or decisions based on this report are the sole responsibility of those parties. This report has been prepared in accordance with generally accepted soil and foundation engineering practices. No other warranty, express or implied, is made.

We trust that this report is satisfies your present requirements, and we look forward to assisting you in the completion of this project. Should you have any questions, please contact the undersigned at your convenience.

Yours truly,

AMEC Environment & Infrastructure
A division of AMEC Americas Ltd



June 6, 2012

John Lobbezoo, P.Eng.
Geotechnical Engineering Services

Reviewed by;

Kevin Spencer, P.Eng.
Associate Geotechnical Engineer

APEGGA PERMIT P04546

Figures

CLIENT LOGO: Stantec	CLIENT: Stantec	DWN BY: BJ	TITLE: BOREHOLE LOCATION PLAN	REV. NO.: A
		CHK'D BY: JL		DATE: JUNE 2012
AMEC Environment & Infrastructure 469 - 40th Street South Lethbridge, Alberta CANADA T1J 4M1 Tel. (403) 327-7474 Fax (403) 327-7682	amec	DATUM: .	PROJECT: River Stone Subdivision Phases 17,21,22 Lethbridge, Alberta	PROJECT NO: BX30201
		PROJECTION: .		
		SCALE: AS SHOWN		FIGURE 1

T:\Drafting\Brent\E&E PROJECTS\LETHBRIDGE\BX30201 – River Stone Subdivision\BX30201.dwg – FIGURE1 – Jun. 22, 2012 9:04am – brent.johnson

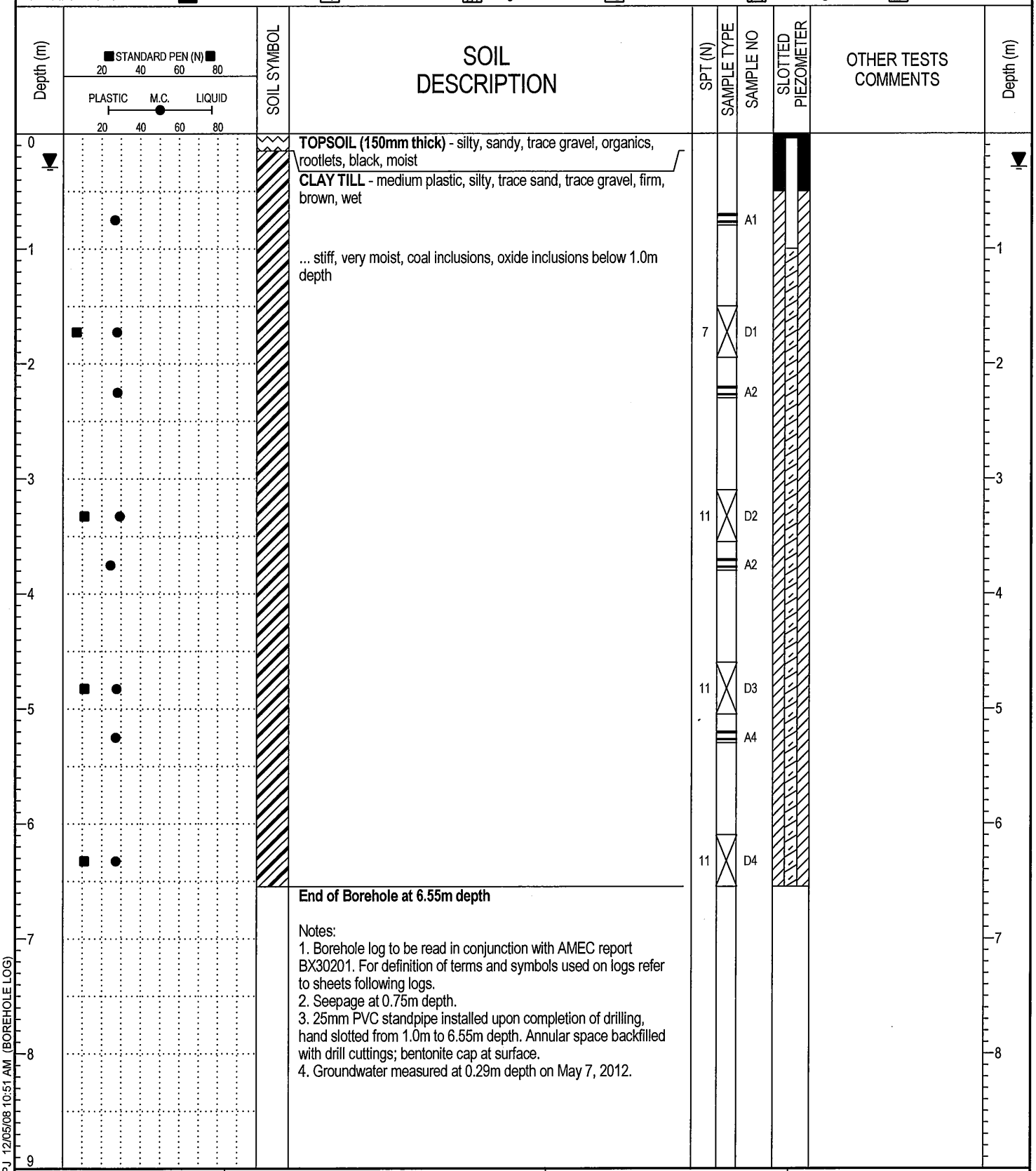
APPENDIX A

Borehole Logs

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-01**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Seepage at 0.75m depth.
3. 25mm PVC standpipe installed upon completion of drilling, hand slotted from 1.0m to 6.55m depth. Annular space backfilled with drill cuttings; bentonite cap at surface.
4. Groundwater measured at 0.29m depth on May 7, 2012.

amec	**AMEC Environment & Infrastructure Lethbridge, AB**	LOGGED BY: SR	COMPLETION DEPTH: 6.55 m
		REVIEWED BY: JL	COMPLETION DATE: 5/1/13
			Page 1 of 1

BHLOGS.GPJ 12/05/08 10:51 AM (BOREHOLE LOG)

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-02**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand

Depth (m) | STANDARD PEN (N) 20 40 60 80 | PLASTIC M.C. LIQUID 20 40 60 80 | SOIL SYMBOL

SOIL DESCRIPTION

TOPSOIL (200mm thick) - silty, sandy, trace gravel, organics, rootlets, black, moist

CLAY TILL - medium plastic, silty, trace sand, trace gravel, stiff, brown, oxide inclusions, coal inclusions, very moist

... moist below 2.75m depth

... thin sand lenses, wet at 3.2 m depth

... stiff to very stiff below 4.5m depth

End of Borehole at 6.1m depth

Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry at completion of drilling.
3. Borehole backfilled with drill cuttings.

SPT (N)	SAMPLE TYPE	SAMPLE NO
		A1
9	D1	
		A2
13	D2	
		A2
15	D3	
		A4

OTHER TESTS COMMENTS

Depth (m)

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AMEC Environment & Infrastructure
Lethbridge, AB

LOGGED BY: SR	COMPLETION DEPTH: 6.10 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13
	Page 1 of 1

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-03**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand

Depth (m)	STANDARD PEN (N) 20 40 60 80 / PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	OTHER TESTS COMMENTS	Depth (m)
0			**TOPSOIL (200mm thick)** - silty, sandy, trace gravel, organics, rootlets, black, moist					0
			CLAY TILL - medium plastic, silty, sandy, trace gravel, firm, brown, oxide inclusions, coal inclusions, very moist			A1		
1			... trace sand below 1.3m depth					1
				5		D1		
2						A2		2
3			... stiff below 2.8m depth					3
				9		D2		
						A2		
4			... sand lens 80mm thick, free water					4
				12		D3		
5						A4		5
6				12		D4		6
			End of Borehole at 6.55m depth					
7			Notes: 1. Borehole log to be read in conjunction with AMEC report BX30201. For definitions of terms and symbols used on logs refer to sheets following logs. 2. Borehole open upon completion of drilling with seepage from 4.0m depth. 3. Borehole backfilled with drill cuttings.					7
8								8
9								

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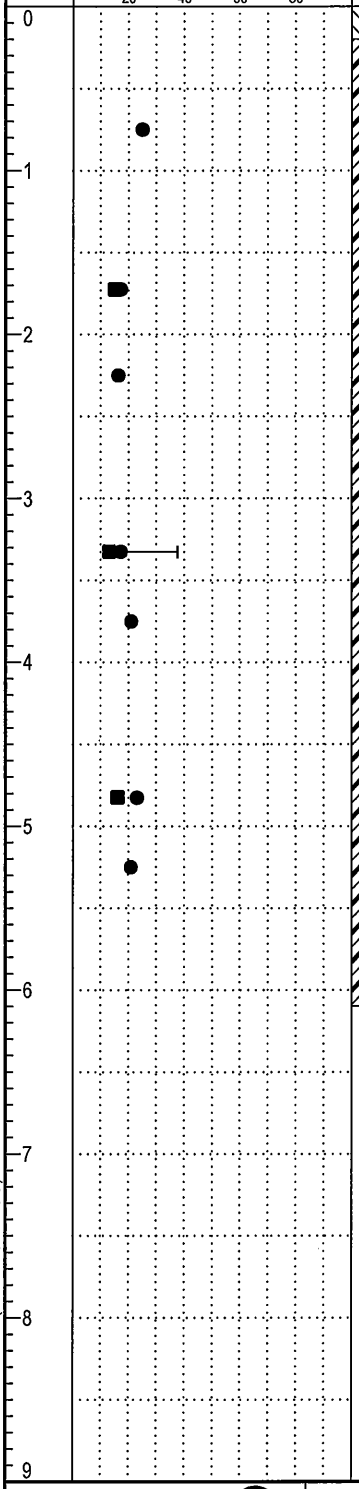
AMEC Environment & Infrastructure
Lethbridge, AB

LOGGED BY: SR	COMPLETION DEPTH: 6.55 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-04**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube | No Recovery | SPT Test (N) | Grab Sample | Split-Pen | Core

BACKFILL TYPE: Bentonite | Pea Gravel | Slough | Grout | Drill Cuttings | Sand



Depth (m)	SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	OTHER TESTS COMMENTS
0		**TOPSOIL (200mm thick)** - silty, sandy, trace gravel, organics, rootlets, black, moist				
		CLAY TILL - medium plastic, silty, trace sand, trace gravel, very stiff, brown, oxide inclusions, coal inclusions, moist			A1	
1						
			15		D1	
2					A2	
3		... stiff below 3.1m depth	13		D2	
					A2	
4		... very stiff below 4.1m depth				
			16		D3	
5					A4	
6		**End of Borehole at 6.1m depth**				
7		Notes: 1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs. 2. Borehole open and dry at completion of drilling. 3. Borehole backfilled with drill cuttings.				
8						
9						

BHLOGS.GPJ 12/05/08 10:51 AM (BOREHOLE LOG)

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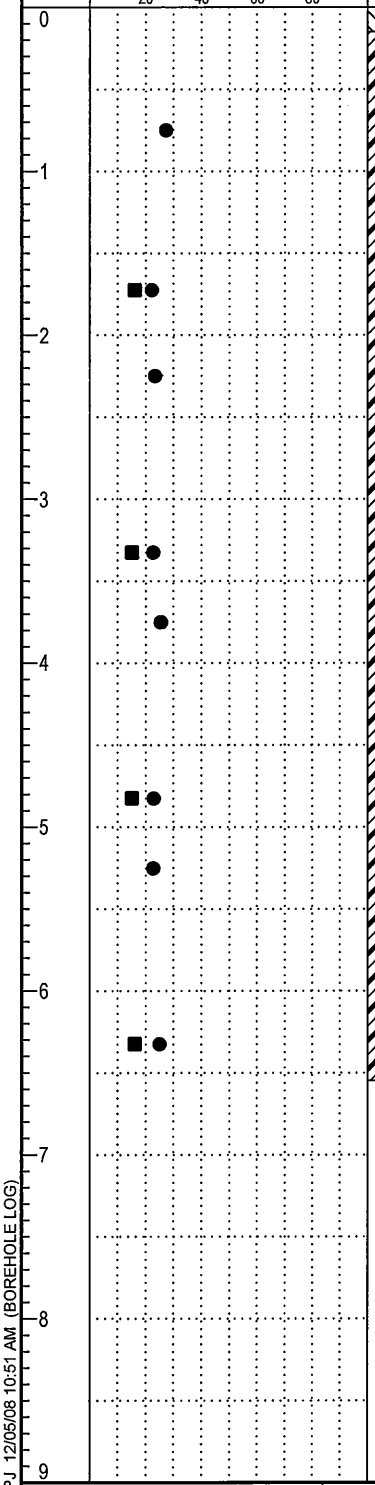
AMEC Environment & Infrastructure
Lethbridge, AB

LOGGED BY: SR	COMPLETION DEPTH: 6.10 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13
	Page 1 of 1

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-05**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



Depth (m)	SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	SLOTTED PIEZOMETER	OTHER TESTS COMMENTS	Depth (m)
0		**TOPSOIL (150mm thick)** - silty, sandy, trace gravel, organics, rootlets, black, moist						0
		CLAY TILL - medium plastic, silty, trace sand, trace gravel, very stiff, brown, oxide inclusions, coal inclusions, moist			A1			
1								1
			16		D1			
2								2
					A2			
3								3
			15		D2			
					A2			
4								4
			15		D3			
5								5
					A4			
6								6
			16		D4			
		End of Borehole at 6.55m depth						
7								7
8								8
9								

Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry upon completion of drilling.
3. 25mm PVC standpipe installed upon completion of drilling, hand slotted from 1.0m to 6.55m depth. Annular space backfilled with drill cuttings; bentonite cap at surface.
4. Borehole was dry at time of groundwater measurement on May 7, 2012.

BHLOGS.GPJ 12/05/08 10:51 AM (BOREHOLE LOG)

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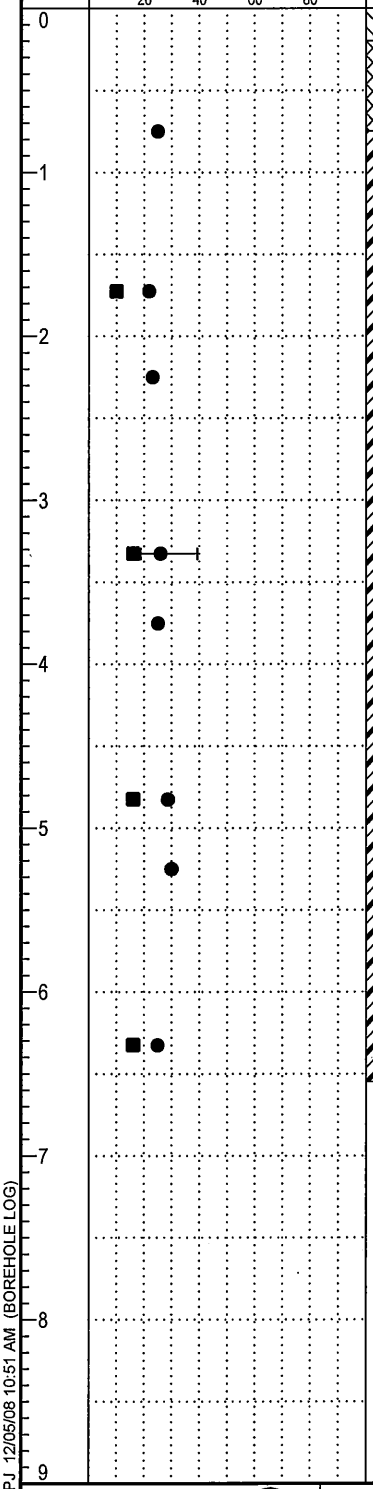
LOGGED BY: SR	COMPLETION DEPTH: 6.55 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13
	Page 1 of 1

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-06**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	OTHER TESTS COMMENTS
	TOPSOIL (200mm thick) - silty, sandy, trace gravel, organics, rootlets, black, moist				
	CLAY FILL - medium plastic, silty, sandy, mottled, stiff, brown, moist				
	CLAY TILL - medium plastic, silty, trace sand, trace gravel, stiff, brown, oxide inclusions, coal inclusions, moist			A1	
		10		D1	
				A2	
	... very stiff below 3.1m depth	16		D2	
	... sandy below 3.5m depth			A2	
		16		D3	
				A4	
		16		D4	
	End of Borehole at 6.55m depth				

Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry at completion of drilling.
3. Borehole backfilled with drill cuttings.

Depth (m): 0 1 2 3 4 5 6 7 8

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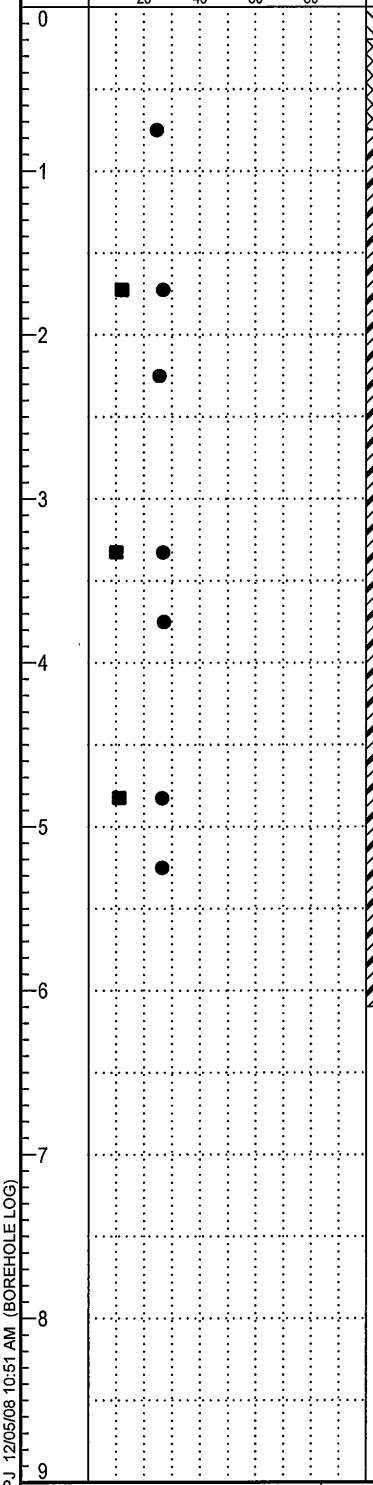
REVIEWED BY: JL	COMPLETION DATE: 5/1/13

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-07**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



Depth (m)	SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	OTHER TESTS COMMENTS	Depth (m)
0		**TOPSOIL (200mm thick)** - silty, sandy, trace gravel, organics, rootlets, black, moist					0
		CLAY FILL - medium plastic, silty, sandy, mottled, stiff, brown, moist					
		CLAY TILL - medium plastic, silty, trace sand, trace gravel, stiff, brown, oxide inclusions, coal inclusions, moist			A1		
1		... white streaks					1
			12		D1		
2					A2		2
3							3
			10		D2		
					A2		
4							4
			11		D3		
5					A4		5
6		**End of Borehole at 6.1m depth**					6
7							7
8							8
9							

Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry at completion of drilling.
3. Borehole backfilled with drill cuttings.

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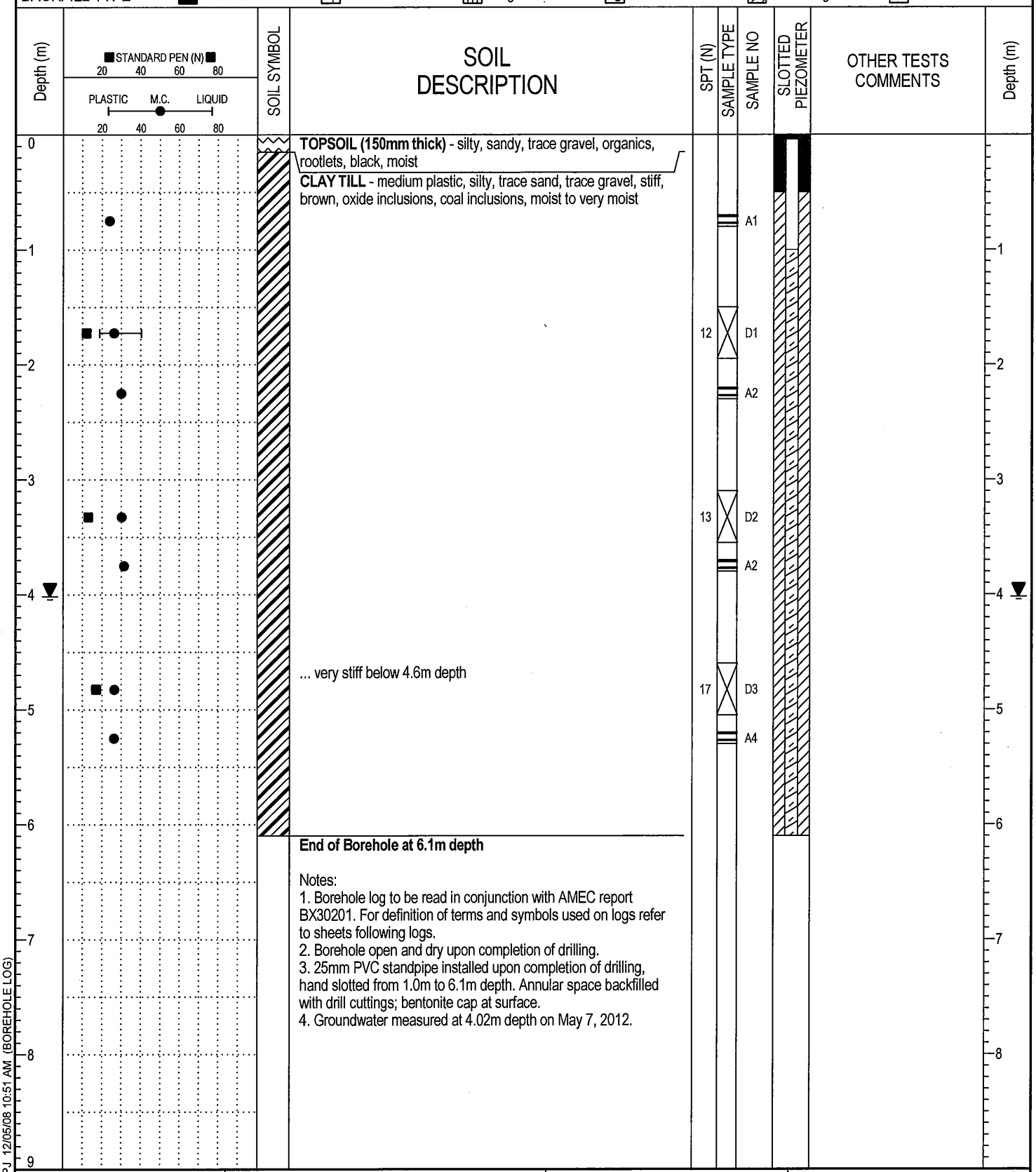
LOGGED BY: SR	COMPLETION DEPTH: 6.10 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13
	Page 1 of 1

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-08**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry upon completion of drilling.
3. 25mm PVC standpipe installed upon completion of drilling, hand slotted from 1.0m to 6.1m depth. Annular space backfilled with drill cuttings; bentonite cap at surface.
4. Groundwater measured at 4.02m depth on May 7, 2012.

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		REVIEWED BY: JL	COMPLETION DATE: 5/1/13
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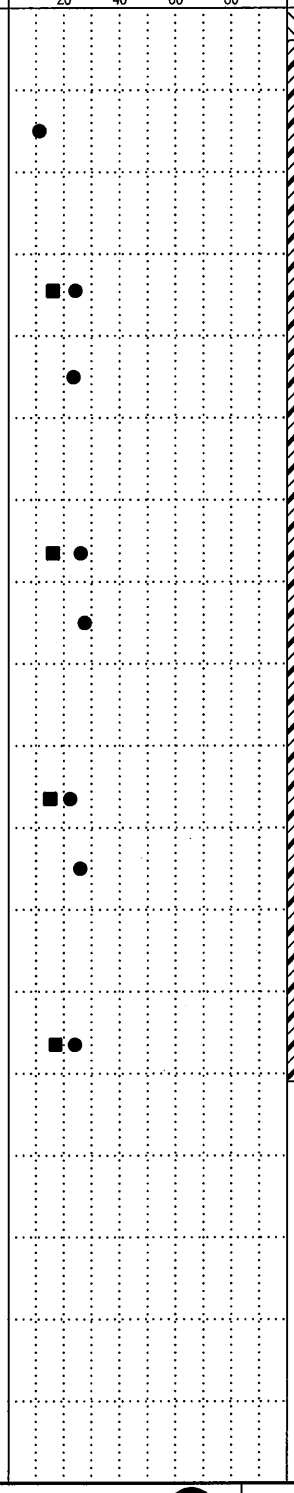
PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-09**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



SOIL SYMBOL	SOIL DESCRIPTION	SPT (N)	SAMPLE TYPE	SAMPLE NO	OTHER TESTS COMMENTS
	TOPSOIL (200mm thick) - silty, sandy, trace gravel, organics, rootlets, black, moist				
	CLAY TILL - medium plastic, silty, trace sand, trace gravel, very stiff, brown, oxide inclusions, coal inclusions, moist			A1	
		16		D1	
				A2	
		16		D2	
				A2	
		15		D3	
				A4	
		17		D4	
	End of Borehole at 6.55m depth				

Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry at completion of drilling.
3. Borehole backfilled with drill cuttings.

Depth (m): 0 1 2 3 4 5 6 7 8

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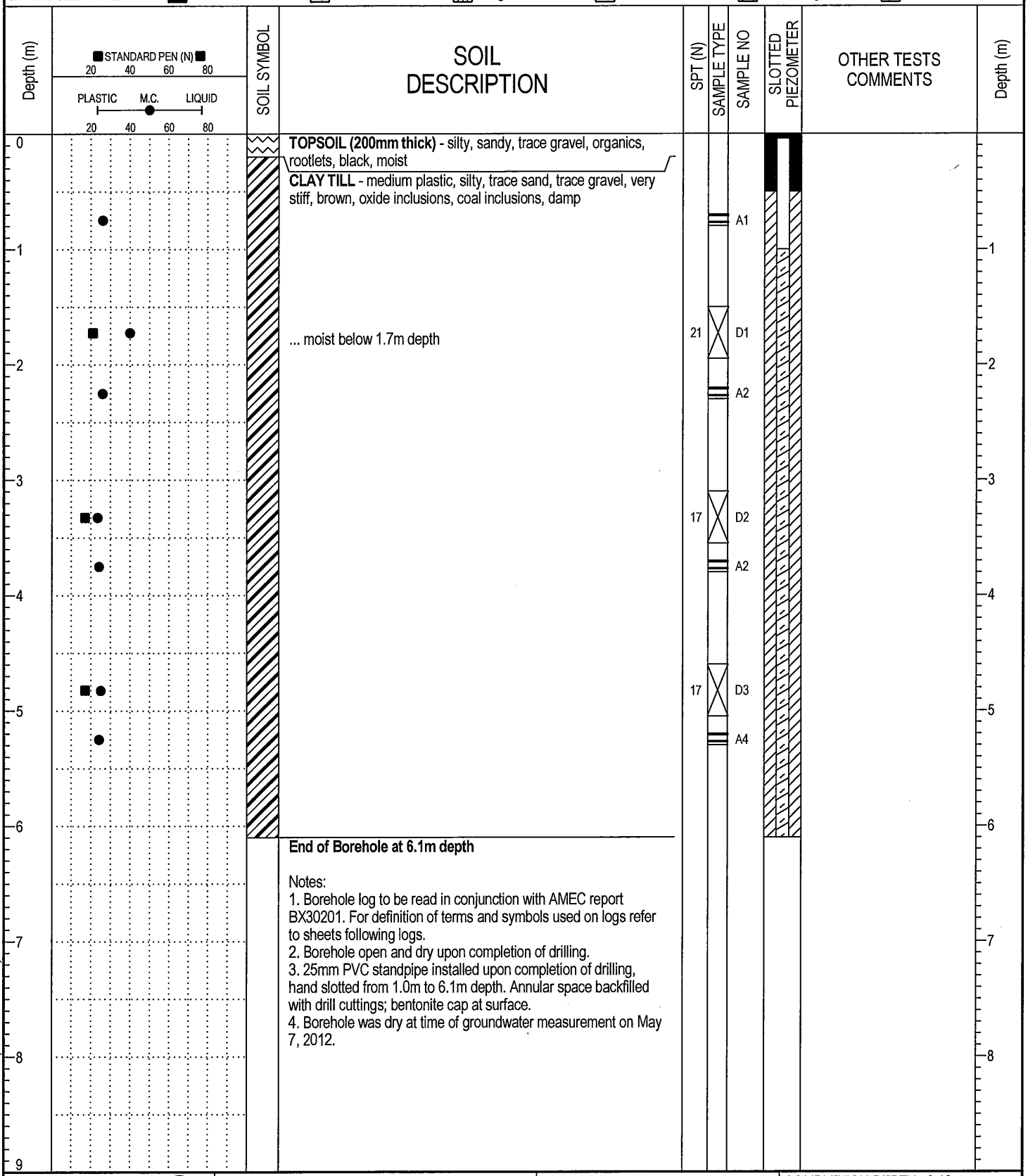
LOGGED BY: SR	COMPLETION DEPTH: 6.55 m
REVIEWED BY: JL	COMPLETION DATE: 5/1/13
	Page 1 of 1

PROJECT: Riverstone Phase 17, 21, 22	DRILLER: Chilako Drilling Services	BOREHOLE NO: **BH12-10**
CLIENT: City of Lethbridge	DRILL/METHOD: Truck Mounted C-1150 Drill/ SSA	PROJECT NO: BX30201
LOCATION: Refer to Figure 1		ELEVATION: -------

SAMPLE TYPE: Shelby Tube; No Recovery; SPT Test (N); Grab Sample; Split-Pen; Core

BACKFILL TYPE: Bentonite; Pea Gravel; Slough; Grout; Drill Cuttings; Sand



Notes:
1. Borehole log to be read in conjunction with AMEC report BX30201. For definition of terms and symbols used on logs refer to sheets following logs.
2. Borehole open and dry upon completion of drilling.
3. 25mm PVC standpipe installed upon completion of drilling, hand slotted from 1.0m to 6.1m depth. Annular space backfilled with drill cuttings; bentonite cap at surface.
4. Borehole was dry at time of groundwater measurement on May 7, 2012.

BHLOGS.GPJ 12/05/08 10:51 AM (BOREHOLE LOG)

amec	**AMEC Environment & Infrastructure Lethbridge, AB**	LOGGED BY: SR	COMPLETION DEPTH: 6.10 m
		REVIEWED BY: JL	COMPLETION DATE: 5/1/13
			Page 1 of 1

EXPLANATION OF TERMS AND SYMBOLS

The terms and symbols used on the borehole logs to summarize the results of field investigation and subsequent laboratory testing are described in these pages.

It should be noted that materials, boundaries and conditions have been established only at the borehole locations at the time of investigation and are not necessarily representative of subsurface conditions elsewhere across the site.

TEST DATA

Data obtained during the field investigation and from laboratory testing are shown at the appropriate depth interval.

Abbreviations, graphic symbols, and relevant test method designations are as follows:

*C	Consolidation test	*ST	Swelling test
D_R	Relative density	TV	Torvane shear strength
*k	Permeability coefficient	VS	Vane shear strength
*MA	Mechanical grain size analysis	w	Natural Moisture Content (ASTM D2216)
	and hydrometer test	w_l	Liquid limit (ASTM D 423)
N	Standard Penetration Test (CSA A119.1-60)	w_p	Plastic Limit (ASTM D 424)
N_d	Dynamic cone penetration test	E_f	Unit strain at failure
NP	Non plastic soil	γ	Unit weight of soil or rock
pp	Pocket penetrometer strength	γ_d	Dry unit weight of soil or rock
*q	Triaxial compression test	ρ	Density of soil or rock
q_u	Unconfined compressive strength	ρ_d	Dry Density of soil or rock
*SB	Shearbox test	C_u	Undrained shear strength
SO_4	Concentration of water-soluble sulphate	→	Seepage
		▼	Observed water level

* The results of these tests are usually reported separately

Soils are classified and described according to their engineering properties and behaviour.

The soil of each stratum is described using the Unified Soil Classification System[1] modified slightly so that an inorganic clay of "medium plasticity" is recognized.

The modifying adjectives used to define the actual or estimated percentage range by weight of minor components are consistent with the Canadian Foundation Engineering Manual[2].

Relative Density and Consistency:

Cohesionless Soils

Relative Density	SPT (N) Value
Very Loose	0-4
Loose	4-10
Compact	10-30
Dense	30-50
Very Dense	>50

Cohesive Soils

Consistency	Undrained Shear Strength c_u (kPa)	Approximate SPT (N) Value
Very Soft	0-12	0-2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

Standard Penetration Resistance ("N" value)
The number of blows by a 63.6kg hammer dropped 760 mm to drive a 50 mm diameter open sampler attached to "A" drill rods for a distance of 300 mm after an initial penetration of 150 mm.

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1 "Unified Soil Classification System", Technical Memorandum 36-357 prepared by Waterways Experiment Station, Vicksburg, Mississippi, Corps of Engineers, U.S. Army. Vol. 1 March 1953.

2 "Canadian Foundation Engineering Manual", 3rd Edition, Canadian Geotechnical Society, 1992.

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	COLOUR CODE	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		RED	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 4;\ C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		RED	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		YELLOW	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			GC		YELLOW	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		RED	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_U = \frac{D_{60}}{D_{10}} > 6;\ C_C = \frac{(D_{60})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		RED	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		YELLOW	SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12 %	ATTERBERG LIMITS BELOW "A" LINE OR P.I. LESS THAN 4
			SC		YELLOW	CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 50\%$	ML		GREEN	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (SEE BELOW)	
		$W_L > 50\%$	MH		BLUE	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDS OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$W_L < 30\%$	CL		GREEN	INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY OR SILTY CLAYS, LEAN CLAYS		
		$30\% < W_L < 50\%$	CI		GREEN-BLUE	INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$W_L > 50\%$	CH		BLUE	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$W_L < 50\%$	OL		GREEN	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	WHENEVER THE NATURE OF THE FINES CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$W_L > 50\%$	OH		BLUE	ORGANIC CLAYS OF HIGH PLASTICITY		
HIGHLY ORGANIC SOILS			Pt		ORANGE	PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBEROUS TEXTURE	

SPECIAL SYMBOLS

LIMESTONE		OILSAND	
SANDSTONE		SHALE	
SILTSTONE		FILL (UNDIFFERENTIATED)	

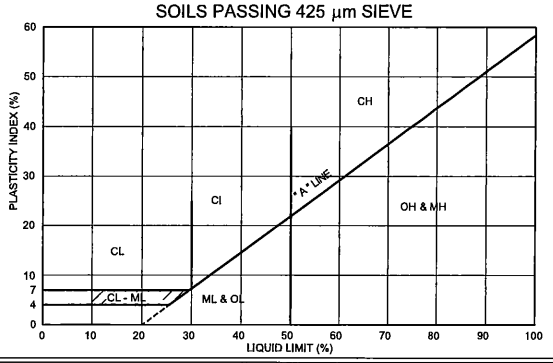
SOIL COMPONENTS

FRACTION	U.S. STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS	
GRAVEL	PASSING	RETAINED	PERCENT	DESCRIPTOR
COARSE	76mm	19mm		
FINE	19mm	4.75mm	35-50	AND
SAND				
COARSE	4.75mm	2.00mm	20-35	Y/EY
MEDIUM	2.00mm	425µm	10-20	SOME
FINE	425µm	75µm		
FINES (SILT OR CLAY BASED ON PLASTICITY)	75µm		1-10	TRACE

OVERSIZED MATERIAL

ROUNDED OR SUBROUNDED:	NOT ROUNDED:
COBBLES 76mm TO 200mm	ROCK FRAGMENTS > 76mm
BOULDERS > 200mm	ROCKS > 0.76 CUBIC METRE IN VOLUME

PLASTICITY CHART FOR SOILS PASSING 425 µm SIEVE



NOTES:

1. ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD A.S.T.M. E.11
2. COARSE GRAIN SOILS WITH 5 TO 12% FINES GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5 AND 12% FINES.

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