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TECHNICAL MEMORANDUM NO. 1 (TM1)

**Blackmud/Whitemud Creek Surface Water
Management Group**

**Blackmud/Whitemud Creek
Surface Water Management Study
Background Data Collection and Review**



August 2016



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TECHNICAL MEMORANDUM NO. 1 (TM1)

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1 Introduction

Associated Engineering (AE) was retained by the Blackmud/Whitemud Surface Water Management Group to complete the Blackmud/Whitemud Creek Surface Water Management Study, which involves hydrologic, hydraulic, hydrogeologic and environmental analyses of the Blackmud and Whitemud Creek basins.

Large portions of the Blackmud /Whitemud Creek watershed are expected to be intensively developed in the foreseeable future by the surrounding municipalities. This development will place additional stresses on Blackmud and Whitemud Creeks, which have already been impacted by previous development.

As part of the study, AE has compiled and reviewed available data for the Blackmud and Whitemud basins. The majority of the documents listed in the terms of reference have been compiled and reviewed, with the exception of two which were not available at the time of writing this memorandum.

This technical memorandum summarizes the results of the background data collection and review. It covers the following:

- Summary of the available data.
- Summary of the review of documents that apply to the study. These documents include, but are not limited to, hydrologic and hydraulic models, hydrogeology of the basins, wetland and natural area studies, and drainage plans.
- Identification of data gaps and outstanding information requested.

2 Available Reports

A number of background reports were provided by the Group. The reports that were relevant to this study are summarized below. Highlighted passages indicate the most important information for this study. Further summary details are presented in [Appendix A](#).

2.1 HYDROLOGY AND HYDRAULICS

[Table 2-1](#) below summarizes the hydrology and hydraulics reports relevant to this study.

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Blackmud/Whitemud Creek
Surface Water Management Study Background Data Collection and Review

Table 2-1: Summary of Hydrology and Hydraulic Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
Blackmud Creek 2014 Sediment and Maintenance Assessment (Sameng Inc)	2014 Leduc County	Reports sediment deposition in Blackmud Creek over the last 10 years and assesses the impact of sedimentation on the capacity of the channel.	Deposition may be due to erosion in the channelized section upstream. Potential for further erosion and deposition should be considered in the present study. Channel Capacity assessment includes channel profiles which will assist in determining model cross sections/slope.
Nisku Flood Hazard Study Blackmud Creek (Northwest Hydraulic Consultants)	2014 Alberta Environment and Sustainable Resource Development	Flood Hazard Study for 12 km along Blackmud Creek.	Up to date model of Blackmud Creek created with validation as well as creek flows and boundary conditions. Most recent hydrological study for the basin.
The City of Edmonton Irvine Creek and Cawes Lake Watershed Study (Stantec Consulting Ltd.)	2014 City of Edmonton	A report discussing the watershed study for Irvine Creek and Cawes Lake	MIKE URBAN and MIKE11 models developed for the Blackmud Creek tributary and contributing area. Appendices contain much background data that may be useful to the present study.
Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 2 Final Report (AMEC Environmental Infrastructure)	2011 City of Edmonton	This study's key objective was to develop a framework for prioritizing repair efforts and applying Permanent Area Contribution funds at erosional sites along the Whitemud and Blackmud Creek basins. The framework follows two distinct processes – (i) pre-screening eligibility and (ii) priority classification. This is the second stage of the project where stage 1 investigated individual erosion sites and a hydraulic model was developed.	Identifies areas where erosion was occurring and the dominant processes.
Leduc County & The City of Leduc Overland Drainage Study (Urban Systems Ltd.)	2010 Leduc County & City of Leduc	Report summarizing the existing natural drainage courses within Leduc County and the City of Leduc with stormwater management facilities recommended in conjunction with future development. Relatively high level analysis. Some drainage courses require upgrades to convey flows. Seven stormwater management facilities were recommended in the study area.	Identifies the condition of existing drainage courses within the study reach with a proposed maximum allowable release rate for future development.
Beaumont Stormwater Management Plan (Focus Corporation)	2009 Town of Beaumont	Stormwater Management Plan reviewing current Town of Beaumont stormwater level of service and evaluation of facility operation during the 1:100 year design storm. Older stormwater facilities in Town do not have capacity for the 1:100 year storm runoff.	Updated LeBlanc Canal Hydraulic Performance model for current and future development.
Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 1 (AMEC Earth & Environmental)	2009 City of Edmonton	This investigation provides a review of the existing studies along Whitemud/Blackmud Creek along with additional analyses to confirm that urbanization within the study basin contributes to an increase in in-stream erosion – beyond erosion expected under natural conditions. A flow duration frequency analysis was conducted to determine the impact of development on the streamflow regime. Through this analysis it was found that future development is expected to increase the duration and frequency of channel-forming streamflows, thus contributing to a net increase in erosive potential. A hydraulic model of the study reaches was constructed from available cross section and return period flow data to provide estimates on hydraulic parameters indicative of stream erosion potential. The model results strongly suggest a net increase in erosive potential downstream of developed areas,	Identifies areas where erosion was occurring with a model of the study reach. Suggests that erosion rates have increased due to urban development.

Table 2-1: Summary of Hydrology and Hydraulic Reports			
Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
		further supporting the assertion that urbanization contributes to increased erosion rates.	
Town of Beaumont LeBlanc Canal Hydraulic Performance Upgrading Analysis (Focus)	2008 Town of Beaumont	Evaluation of canal hydraulic capability to serve future land development outside of the Town of Beaumont. Existing channel would provide sufficient capacity if it is cleaned but downstream flows could be increased	Identified improvement options for increasing LeBlanc Canal capacity but did not analyse effects on Irvine Creek downstream.
Flood Level Determination for Blackmud Creek: NE 6-51-24-W4 Block B, SE 6-51-24-W4 Lot F (Sameng Inc.)	2007 Leduc County	The purpose of this study was to determine the flood levels along the Blackmud Creek within the studied properties, determine if the parcels of land could be filled on the west side of the creek to provide developable land that would not be flooded by a 1:100 year event, and to determine the impacts of such filling on the upstream properties.	Flood level determination for Blackmud Creek at study location.
“East Vistas” Local Area Structure Plan NE ¼ 31-50-4-W4 100-Year Floodplain Study Irvine Creek (River Engineering Consulting)	2007 Scheffer Andrew Ltd.	Report outlining delineation of floodway/flood fringe for Irvine Creek through local area structure plan area.	100 year flood levels as well as limited morphological assessment for Irvine Creek through study location.
Airport Road Watershed Study Final (Bel-MK Engineering Ltd.) 2005	2005 City of Leduc	Watershed study for developments discharging to an unnamed tributary of Blackmud Creek north of Airport Road.	The report defines the basin area boundaries for the tributary and identifies service basins in conjunction with their respective flows. Recommendations for monitoring water flow and quality are provided as well as identification of required upgrading for the tributary.
Leduc County NE7 & NW 8-50-24-4 100-Year Flood Plain Study Blackmud Creek (River Engineering Consulting)	2005 Scheffer Andrew Ltd.	Report mapping floodway/flood fringe limits through area structure plan location. Proposed solutions for development of filling land in flood fringe area.	Annual maximum flow series and 100 year flood levels for Blackmud Creek through study reach.
Deer Creek 1:100 Years Floodplain Analysis in SE ¼ Sec. 33-49-25-4 (Challenger Engineering)	2004 City of Leduc & Alberta Public Lands & Forests	1:100 year floodplain analysis of Deer Creek through the proposed Deer Valley subdivision, establishing the horizontal and vertical distance from the creek for environmental reserve and back of lot elevations.	100 year flood levels through study area for Deer Creek tributary of Whitemud Creek.
Nisku Industrial Business Park Design Flows Review (EXH Engineering Services Ltd.) 2004	2004 Leduc County	Justification for the requirement of having a consistent design flow estimate, including predevelopment maximum design flows for the Nisku Industrial Business Park for Leduc County’s Stormwater Management Plans. Important since flows from the Nisku Industrial Business Park drain into the Blackmud Creek.	Pre and post development rates draining into Blackmud Creek basin.
Inter Municipal Drainage Study Whitemud Tributary Leduc County – City of Leduc (GPEC)	2001 City of Leduc & Leduc County	Presentation of a typical watershed plan for the Whitemud Tributary known as Deer Creek which was based on computer modelling of the watershed and Whitemud Tributary. Results indicated that the channel provided an acceptable level of flood protection for existing land uses.	Watershed plan for Whitemud Creek tributary Deer Creek which runs through the City of Leduc.
Inter Municipal Drainage Study on LeBlanc Canal (GPEC)	2001 Leduc County & Town of Beaumont	Inter-municipal drainage study on Leblanc Canal for the Town of Beaumont and Leduc County. The canal provides drainage for agricultural lands surrounding the Town of Beaumont, and the southwest, southeast and northwest quadrant of the Town and ultimately drains into Irvine Creek.	Flows and drainage upstream of Irvine Creek tributary of Blackmud Creek. Modelling system used was USEPA SWMM4.

Table 2-1: Summary of Hydrology and Hydraulic Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
		Flooding occurs at locations along the length of the Canal during relatively minor rainfall events and significant flooding is experienced in moderate to heavy rainfall events.	
Leduc County Nisku Industrial Business Park Storm Water Drainage Plan Preliminary Engineering Study (EXH Engineering Services Ltd.)	2001 Leduc County	Report outlines the results of storm water management analyses of the Nisku Industrial Business Park drainage basins into Blackmud Creek, using a hydraulic model of the area. It was determined that generally for existing and future development, the storm system capacity is adequately sized to accommodate the 1:5 year design storm event. A long-term management policy is recommended to be implemented to restrict the runoff.	A bit dated but reports Nisku runoff rates developed for 1:25 year 24 hour storm.
Whitemud Creek Watershed Plan Update Final Report (Cochrane Engineering) 1999	1999 City of Edmonton	Updated report following the 1983 Watershed Plan Study completed by ECOS Engineering Services Ltd. A detailed assessment of the downstream sections of the Whitemud and Blackmud Creeks, including a review of alternatives for rehabilitating actively eroding sites and bank instabilities was recommended.	Watershed plan with pre-development release rate calculations.
Irvine Creek Water Management Project Including the LeBlanc Ditch and the Foley Lake Drainage System Preliminary Engineering Report (Samide Engineering Ltd.)	1991 Strathcona County & Leduc County	Report outlines recommendations regarding the proposed Irvine Creek Water Management Project located just north and east of the Town of Beaumont. Installation of drop structures, channel improvements, culverts, and control structures were recommended after running a HYMO model to simulate various floods on lake levels and outflows.	Tributary flows to Blackmud Creek. As of 2009, no upgrading of the LeBlanc Canal has taken place and hydraulic evaluations have shown that portions of the Canal do not have capacity.
Blackmud Creek Floodplain Study Saunders Lake to Highway 2 (B.G. Bigornia, P. LaRocque)	1985 Alberta Department of the Environment Water Resources Management Services	Outlining a study undertaken to determine the water surface profiles and flood risk areas along Blackmud Creek about 10 km between Saunders Lake and Highway 2. These flood risk areas were delineated for the 1:100 and 1:25 year floods.	Historical floodplain delineation for Blackmud Creek.
Blackmud Creek and Irvine Creek Drainage Improvement Project (Stewart, Weir & Co.)	1983 Leduc County	Proposed drainage improvements of Blackmud and Irvine Creeks to reduce the frequency and duration of flooding.	Blackmud Creek and tributary flows.
City of Edmonton Watershed Plan Study for the Whitemud Creek Basin (ECOS Engineering Services Ltd.)	1983 City of Edmonton	Plan study identified the need for stormwater management and limiting the increase in runoff from urbanization to the Blackmud and Whitemud Creek basins.	Preliminary Whitemud Creek basin watershed plan for development to use as a basis for design.
Blackmud Creek Storage Channel (Stewart Weir et. al.)	1981 Leduc County	Proposal of utilizing Blackmud Creek as a storm detention pond for the Nisku area. It was concluded that the use of Blackmud Creek as a storage channel was feasible and more economical than having storm ponds for each subdivision.	Blackmud Creek flows circa 1981.

Table 2-1: Summary of Hydrology and Hydraulic Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
Nisku Stormwater Management Study (Associated Engineering Services Ltd.)	1981 Alberta Transportation & Sparrow Developments Ltd.	Study conducted to expand and refine the drainage scheme along Highway 2 from the City of Leduc through Nisku, provide recommendations to minimize erosion and maximize flood protection, and to verify the practicality of the drainage scheme proposed by Alberta Transportation.	Stormwater management plan for areas draining north towards Blackmud Creek.

2.2 HYDROGEOLOGY

Table 2-2 below summarizes the hydrogeological reports relevant to this study.

Table 2-2: Summary of Hydrology and Hydraulic Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
The City of Edmonton Irvine Creek and Cawes Lake Watershed Study	2014 City of Edmonton	To complete a watershed study for Irvine Creek and Cawes Lake. Groundwater general information was discussed for Blackmud/Whitemud Creek Surface Water Management and is perhaps the most relevant information of the reports reviewed.	A lack of groundwater monitoring and specific conceptual model for the study area could cause both quantity (erosion, reduction of recharge and baseflow) and quality issues for both surface water and groundwater due to future development. As groundwater and surface water resources are integrated, changing the conditions in one will influence the other. Using existing water well information, ground truthing through a well audit program and adding this information into a 3D conceptual model can be advantageous to the surface water management of Blackmud and Whitemud Creeks.
Desktop Geotechnical Review, City of Leduc West of ASP Area NW & SW Quarter Section 28-49-25-4 and Quarter Ssection 28-49-25-4	2013 IBI Group	Geotechnical investigation as part of a Phase I Environmental Site Assessment.	Brief information on the hydrogeology in this report only gives estimates of groundwater levels between 3 and 6 m and very general lithology information. Till from surface to 6 m and up to 12 m below surface with bedrock shale below. No major influence is expected on the management study apart from potential seepage zones at the local creeks if they are incised deep enough.
Geotechnical Investigation West End Fire Hall Part of NW ¼ 28-49-25 W4M, Leduc Alberta	2013 S2 Architecture	Geotechnical investigation for the proposed West End Fire Station Hall.	Small footprint compared to the overall site without much groundwater information. No other aquifer characteristics were available from this report.
Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 1.	2009 City of Edmonton Drainage Services	Overview of studies reviewed and flow frequency analysis to determine impact from developments on streamflow regime based on in-stream erosion.	Hypothesises the relationship of a reduction in evapotranspiration and increase in watering of lawns with increasing groundwater levels. Increasing groundwater levels are also mentioned as processes that could increase bank instability and cause erosion, however no additional work was performed in this study on the subject.
Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation.	1982 Ecos Engineering Services Ltd. and City of Edmonton	A report discussing the geotechnical and environmental input to the development of a watershed plan for a portion of the Whitemud and Blackmud Basins.	Hydrogeology indicates the importance of aquifers and their relationship to specific lithological units. These units will have connection to the two creeks and will impact the baseflow to the creeks in addition to the erosion. Seepage in the permeable units above bentonite or bedrock in contact with the creeks will have higher erosion rates. This is more evident in the Whitemud Creek than the Blackmud Creek.
Hydrogeology of the Southwest Segment Edmonton Area, Alberta	1979 Research Council of Alberta	Hydrogeology of the southwestern portion of Edmonton including explanation of aquifers, lithology, hydrogeological parameters etc. The map covers the major municipalities of Leduc, Millet, Calmar and Beaumont.	General information on groundwater levels, permeability of aquifer, type of geology materials and the interactions between surface and groundwater related to erosion and recharge issues. The following are general important groundwater related characteristics: <ul style="list-style-type: none"> Groundwater flow regionally is mainly from southwest to the north towards the North Saskatchewan River; and north of the River it is southwards towards the River. There is an evidence of limited groundwater flow locally towards the Blackmud Creek, only where incisions are deep enough.

Table 2-2: Summary of Hydrology and Hydraulic Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
			<ul style="list-style-type: none"> • Recharge occurs mostly in the upland area adjacent to the Pigeon Lake in the unconsolidated Quaternary sediments and deeper into the Paskapoo sandstone/siltstone formation. More permeable unconsolidated units (buried valleys) will also contribute to groundwater recharge, such as the quaternary sediments in between Woodbend and Golden Spike and also in the Millet area. • Recharge in the rest of the project area associated with the more clayey, less permeable quaternary sediments will be fairly low. • Calcium-magnesium bicarbonate type groundwater dominates in the surficial deposits and sodium bicarbonate in the bedrock deposits. • Nitrate contamination is evident in the surficial drift sediments. • Deeper Paskapoo bedrock formations are the highest yielding aquifers in the area with up to 38 L/s, followed by the Horseshoe Canyon bedrock aquifer with up to 7.6 L/s. The clay till areas are mostly associated with well yields less than 2 L/s. • Groundwater levels range from 825 m amsl in the higher topographical areas to 700 m amsl in the Northern Saskatchewan River area where it discharges. No information is given on levels below ground surface in this report. • Only the southernmost portion of the Whitemud Creek catchment would have potential issues with the Creek intercepting Paskapoo sandstones that could have associated high seepage rates into the Creek banks and cause erosion. The Southeastern section of the Blackmud Creek could intercept the Horseshoe Canyon Formation sandstone and bentonitic mudstone and Shale beds that could have seepage zones with slightly higher groundwater seepage flows causing erosional features. • The northern areas in both catchments will be associated with up to 15 to 30 m thick clayey till material with low permeability and less seepage issues.

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The Alberta Water Well Information Database (AWWID) is a provincial database that contains groundwater information for specific areas from well lithological logs, to help characterize aquifers for a geographical area in Alberta. In addition to the reports reviewed, this database will provide more information of the hydrogeology of the study extent. This database is updated regularly.

Well information within the study extent was extracted from the AWWID on September 19, 2016. There are 3776 records for the Blackmud Creek area and 1269 for the Whitemud Creek area. The following additional information was sourced from the AWWID relevant to the study and are discussed under each area as follows:

- Blackmud Creek
 - Average well depth is 50.76 m.
 - Average static groundwater level is 11.88 m below ground surface (m bgs). The well depths and water levels indicates that the wells are likely established in the sandstone bedrock formations of the Horseshoe Canyon sandstones and the Paskapoo sandstones.
 - The average well yield is 0.4 l/s, this indicates lower permeable aquifers, which is typical of low density fractured bedrock aquifers.
 - The average screen depth of wells indicates that the permeable aquifer section is 45 m bgs.
- Whitemud Creek
 - Average well depth is 49.26 m.
 - Average static groundwater level is 13.04 m bgs.
 - The average well yield is 0.5 l/s.
 - The average screen depth of wells in this area indicates that, the permeable aquifer sections is 33.95 m bgs and likely established in the sandstone bedrock formations of the Paskapoo Fomation.

Based on the above information, the till/drift clays in the Blackmud Creek catchment is likely thicker in the upper section with sandstone/shale bedrock situated below the upper clays. The Whitemud Creek catchment is similar, however the upper till/drift material is not as thick and bedrock is likely closer to surface within the first 13 m bgs. The well information also indicates that the aquifers within the study extent are not highly permeable. The static water levels are deeper than the general clay layer thickness. This indicates that the clays are fairly impermeable and act as aquitards with reduced recharge from direct precipitation. Based on this, areas with increased pavement will not have an impact on groundwater recharge.

There are minimal wells completed in the upper till/clay layers, therefore it is difficult to estimate the groundwater table for these areas, however seepage from this layer into the stream banks at lithological contacts are likely to experience low flows which can be mitigated. It also indicates that a deep channel will expose bedrock in the south Whitemud area and to a lesser extent in the south Blackmud area. It is also expected that these southern areas will contribute to baseflow where the permeable sandstone is in contact with the streams/creeks and lakes. This will have to be confirmed using hydrometric gauge stations within the creeks, hydrograph separation techniques or a numerical groundwater model.

2.3 ENVIRONMENTAL

Table 2-3 below summarizes the environmental reports relevant to this study.

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Table 2-3: Summary of Environmental Reports

Title	Year and Client	Purpose	How does this affect our Blackmud/Whitemud Creek Surface Water Management Study
Leduc County Environmentally Significant Areas Study (Fiera Biological Consulting)	2015 Leduc County	Environmentally significant areas were mapped. As part of this process, mapping of important data such as wetlands and land cover were completed.	GIS data associated with this report would be an important resource for the environmental studies to be completed as it would provide spatial data on wetlands and land cover and incorporated into the wetland inventory and functional analysis to be performed. However, the County has indicated these data are not available. The location of Environmentally Significant Areas within the study area provide useful information regarding ecological health and stressors and relate to management and protection priorities.
Environmentally Significant Areas in Alberta: 2014 Update (Fiera Biological Consulting) 2014	2014 Government of Alberta	Areas identified as having high environmental significance were mapped and scored on a quarter section basis for important criteria such as contribution to water quality.	The location of Environmentally Significant Areas within the study area provide useful information regarding ecological health and stressors and relate to management and protection priorities.
Irvine Creek and Cawes Lake Watershed Study (Stantec Consulting Ltd)	2014 City of Edmonton	Watershed study for the City of Edmonton for Irvine Creek and Cawes Lake to determine potential for post-development storm drainage.	This studied identified and mapped terrestrial and aquatic resources, which will be a useful reference when compiling similar data for natural resources within the Blackmud and Whitemud Creek basins. Provides baseline water quality data for Irvine Creek. Provides sources of information that should be investigated to yield more data. Information also to used to guide the development of future monitoring plans, if recommended.
Limited Phase I Environmental Site Assessment and Phase II Environmental Site Assessment Leduc Recreation Centre 4330 Black Gold Drive Leduc, Alberta (AMEC Environment and Infrastructure)	2012 City of Leduc	Environmental Site Assessment (Phase I/II) of the Leduc Recreation Centre 4330 Black Gold Drive, Leduc AB.	Establishes historical surface water quality of the storm water pond in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized storm water inputs to creeks, tributaries, wetlands in the local area. Information also to used to guide the development of future monitoring plans, if recommended.
Telford Lake Master Plan: Biophysical Review of Sensitivities and Opportunities (Spencer Environmental)	2010 ISL Engineering and Land Services	A biophysical review for a Master Plan was completed for Telford Lake. The study was completed to guide the long-term protection and management of Telford Lake as a natural feature.	A high level review of the Blackmud/Whitemud Creek study area will include similar information. This report can contribute to the understand of natural resources in the study area. Provides seasonal baseline water quality data for Telford Lake in 2009 including detailed water quality parameters.
Proposed Bridgeport Regional Shopping Centre Road Crossing of Deer Creek – Fish and Fish Habitat Assessment (Westworth Associates Environmental Ltd.)	2001 City of Leduc	A review of existing fisheries information for the Deer Creek was developed in support of a proposed road crossing.	A high level review of the Blackmud/Whitemud Creek study area will include similar information. This report can contribute to the understanding of natural resources in the study area.
Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation (Hardy Associates Ltd)	1982 Ecos Engineering Services Ltd. & City of Edmonton	Environmental and geotechnical assessment for the Whitemud/Blackmud drainage basins.	Establishes historical surface water quality of the watersheds, in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized discharges to creeks, tributaries, wetlands in the local area. Provides sources of information that should be investigated to yield more data.

3 Conclusions

The following are key conclusions from the background review of the available reports:

- The following reports will be vital for this study: Irvine Creek and Cawes Lake Watershed Study by Stantec (ongoing), Town of Beaumont Stormwater Management Plan (2016) by FOCUS, Nisku Flood Hazard Study (2014) by Northwest Hydraulic Consultants (NHC), and Whitemud Blackmud Creek Erosion Phase I- Final Report (2009) by AMEC.
- The models developed by Stantec, FOCUS, NHC, and AMEC will provide a head start for this study. Most of these models have been requested and are still outstanding.
- The LeBlanc Canal handles the majority of the Town of Beaumont runoff but has limited capacity. The Creek is shallow and has been previously modified. The Irvine Creek which flows into the Blackmud Creek receives the entire LeBlanc Canal flow.
- The City of Edmonton currently has permanent area contributions (PAC) in place for all developments along the Whitemud Creek.
- Detailed LiDAR covering the City of Leduc and part of the City of Edmonton is available. AE has requested this data from the two municipalities. A 15 m LiDAR resolution is available and has been obtained for the entire basin (downloaded from www.altalis.com). The 15 m LiDAR will be used to confirm delineation of the Blackmud and Whitemud basins to understand the overall drainage pattern.
- Limited information was provided for the as-built drawings. In the absence of as-built drawings, AE will estimate flows from outfalls into the creeks based on topography, air photos, land use maps and available data.
- Environmental reports that were reviewed, apply to small geographical areas within the Blackmud and Whitemud Creek basins, and compilation of these data is not practicable for the scale of this project. Therefore, the review of available environmental information will rely on other available data (e.g. provincial databases).
- Wetland inventories in GIS format were requested from jurisdictions in the study area but only limited data was provided. Provincial wetland inventory has coarse level of accuracy. Therefore, AE will generate new wetland data in critical locations of the study area.
- There is a lack of baseline water quality data for Whitemud/Blackmud drainage basins. Some historical water quality data was obtained from few watershed reports. However, this data was limited to routine water parameters such as dissolved oxygen, conductivity, pH and temperature. In addition, it was for watercourses/waterbodies in the vicinity of Leduc (e.g., Whitemud Creek, Deer Creek). AE will conduct additional literature reviews, contact institutions, and search government of Alberta databases for water quality information. AE will also identify intakes/water users (municipal, industrial), and effluent discharges (municipal treatment plants, lagoons, and industrial discharges) within the drainage basins, and contact them for available water quality data.
- The Whitemud Blackmud Creek Erosion Phase I and Phase 2 studies will provide relevant information for the morphological assessment for the Blackmud and Whitemud creeks.



**City of Edmonton, City of Leduc, Strathcona County
Leduc County, Town of Beaumont**

- There were no reports for studies completed specifically for hydrogeology in the Blackmud and Whitemud Creeks catchments. However, some reports reviewed and discussed the hydrogeology as part of an overall study.
- There are no models that identified the different aquifers within the study extent and how they integrate and interact with the Creeks.
- Due to limited gauge stations and understanding of permeability characteristics of aquifers and storage, it will be difficult to accurately estimate baseflows for inputs into surface runoff models pertinent to the study.
- The desktop review of the hydrogeology of the study extent indicated that the groundwater types within the study extent are mainly calcium-magnesium bicarbonate groundwater in the surficial deposits and sodium bicarbonate type groundwater in the bedrock deposits. It also indicated that the groundwater has high concentrations of nitrates and high total dissolved solids in deeper bedrock aquifers.
- A high level review of available data from Alberta Water Well Information Database (AWWID) was also completed to get a better understanding of the hydrogeology of the study extent. The following is a summary of the AWWID data review:
 - Wells in the area are mostly drilled and screened within the permeable sandstone aquifers below the till clay layers.
 - In a large portion of the study extent, the till clay upper layer is mostly an aquitard, which will allow very little direct recharge to aquifers below.
 - Aquifer recharge in the sandstones will occur in higher topography, south of the study extent, where bedrock is in contact with the surface.
 - Baseflow can be estimated in areas where sandstones are in contact with the streams/creeks using analytical equations.
 - The groundwater table within the till clays can't be determined because the average screening depth indicates wells are screened mainly in the deeper bedrock aquifers, hence groundwater levels are likely pressurised.
 - Hydraulic gradients are mimicking topography, therefore high groundwater flow rates discharging into the creek are not expected.

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Closure

This Technical Memorandum (TM1) was prepared for the Blackmud/Whitemud Creek Surface Water Management Group to summarize the background data collection and review documents.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this TM1 were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
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PERMIT STAMP

Appendix A – Summary Details

Hydraulic/Hydrologic Report Summaries

Ref #	Year	Title	Author
3.1	2014	Blackmud Creek 2014 Sediment and Maintenance Assessment	Sameng Inc.
Summary			
<p>The Blackmud Creek from Saunders Lake to Highway 2 (10 km) was improved in the winter of 1983-84. Sameng Inc. assessed the levels and effects of sedimentation which have between 2004 and 2014 on lowering the capacity of the improved channel and what maintenance would be necessary to re-establish the channel capacity to its originally constructed levels. The following conclusions and recommendations were outlined:</p> <ul style="list-style-type: none"> • The sediment deposition rate over the entire Blackmud Creek channel has slowed down by 50% over the last 9 years when compared with the first 20-year period post-construction. • No significant sedimentation is found in the upstream and some of the downstream reaches. In midstream, sediment filled in the low spots before 2004, but no significant change since then has been noted. • Rapid sediment buildup is observed within the segmental channel from Station 5+000 to 8+000. • The existing capacity of the Blackmud Creek channel has not been significantly reduced from its 1984 constructed capacity; however, the sedimentation built up in downstream has raised the bed to become above the as-built grade. • Sedimentation removal work is recommended for downstream reach from Station 6+000 to 9+000. The cost is estimated as \$74,200, not including any additional fees for energy/utility line crossings and fisheries requirements. • Floodplain delineations for the Blackmud Creek based on the existing and future development plans are also recommended for rolling out the guidelines and sediment control practices. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Sedimentation affects the hydraulic capacity of the creeks so this information is important in calibrating/validating model results.			

Ref #	Year	Title	Author
3.2	2014	Nisku Flood Hazard Study Blackmud Creek	Northwest Hydraulic Consultants
Summary			
<p>A flood hazard study for a 12 kilometer reach along Blackmud Creek in Leduc County was conducted, extending from the outlet of Saunders Lake to the north boundary of Leduc County located at 41st Avenue SW in south Edmonton. Flood discharges on Blackmud Creek for 2-year to 1000-year return periods were estimated using peak discharges recorded by WSC at the Blackmud Creek near Eilerslie gauge, a crest-stage gauge on Blackmud Creek in the vicinity of Nisku operated by ESRD, as well as several regional gauges. The Blackmud Creek 100-year flood adopted for the study is 78 m³/s in the lower reaches of the model domain. The hydraulic model was calibrated using highwater marks measured during the 1974 flood at the inlet and outlet of the QE2 Highway southbound culvert. In addition, air photos taken 11 days after the 1974 flood peak and two approximate highwater marks provided by a landowner were used to calibrate the model. Flood frequency maps showing the limits of the 10-, 50-, and 100-year open water floods throughout the study reach were produced. The mapping indicates that at the 100-year flood there would be significant flooding along the upper eight kilometres, extending from the Saunders Lake outlet to about 30 Avenue in Nisku, where the width of the flooded areas would be about 500 metres. Between 30 Avenue and the QE2 Highway there is considerable out of bank flooding, but the flooded width is greatly reduced due to overbank topography. Between the QE2 Highway and the downstream mapping boundary, 41 Avenue SW in Edmonton, the 100-year flood is primarily in-bank with only occasional out of bank flooding. Flood hazard and flood frequency maps are located here. Airport Road and 9 Street in Nisku would be inundated at the 50-year flood. There would be some minor backwater flooding extending up Clearwater and Irvine Creeks. The lower area of three residences would be affected as well as several garages, outbuildings, and industrial areas.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>This is an existing model which could be built upon for the current study model with valuable calibration/validation.</p>			

**City of Edmonton, City of Leduc, Strathcona County
Leduc County, Town of Beaumont**

Ref #	Year	Title	Author
3.3	2014	The City of Edmonton Irvine Creek and Cawes Lake Watershed Study	Stantec Consulting Ltd.
Summary			
<p>Stantec Consulting Ltd was retained by the City of Edmonton to complete a watershed study for Irvine Creek and Cawes Lake. This study had the following goals:</p> <ul style="list-style-type: none"> • Assess existing aquatic and terrestrial habitat within the watershed and identify opportunities for restoration or improvement of habitat within the watershed, specifically Cawes Lake • Identify the Irvine Creek Flood Plain and provide options to reduce flooding and erosional impacts • Review the LeBlanc Canal drainage basin and provide mitigation measures to reduce flooding and erosional impacts • Review existing regulations related to potential modifications to waterways, wetlands, and wildlife habitat in the Irvine Creek watershed • Develop guidelines for stormwater management practices for the Irvine Creek and Cawes Lake watershed in Leduc County and the City of Edmonton. The practices must conserve and enhance the existing natural features in the watershed and minimize the impacts of future development on the watershed • Recommend measures to improve downstream conditions and methods to compute Permanent Area Contributions (PAC) for erosion control for the Irvine Creek Basin 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
The study identified constraints including existing issues and challenges within the watershed. Goals were defined and watershed management options were identified. This will affect modelling of future development.			

Ref #	Year	Title	Author
3.4	2011	Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 2 Final Report	AMEC Environmental Infrastructure
Summary			
<p>This study's key objective was to develop a framework for prioritizing repair efforts and applying Permanent Area Contribution funds at erosional sites along the Whitemud and Blackmud Creek basins. The framework follows two distinct processes – (i) pre-screening eligibility and (ii) priority classification.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Identifies areas where erosion is occurring.			

Ref #	Year	Title	Author
3.5	2010	Leduc County & The City of Leduc Overland Drainage Study	Urban Systems Ltd.
Summary			
<p>Urban Systems Ltd. conducted an Overland Drainage Study to identify potential drainage and erosion issues for an area of approximately 4,000 ha located within Leduc County and the City of Leduc. The existing natural drainage courses within the study area drain towards Saunders Lake and it was indicated that under pre-development conditions the existing drainage courses have the capacity to convey flows from minor storm events. However, under certain major storm events, there are some drainage courses that require upgrades to convey flows. Seven stormwater management facilities were recommended in the study area.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Overland drainage paths within the study area.			

Ref #	Year	Title	Author
3.6	2009	2009 Beaumont Stormwater Management Plan	Focus Corporation
Summary			
<p>Focus Corporation provided a Stormwater Management Plan that lists drainage basins, current and future stormwater facilities and presents a system analysis for the Town of Beaumont. The study involved the following aspects:</p> <ul style="list-style-type: none"> • The collection and review of all relevant existing reports, standards and data for the assessment of the stormwater management system. • A summary of the existing and proposed SWMFs. • The evaluation of the existing major storm management system; identifying deficiencies and areas for improvement. • The existing PCSWMM™ model upgrade and development. • Proposed maintenance for existing / future SWMFs. <p>An existing scenario was built by modification of the existing LeBlanc Canal Hydraulic Performance model and a built-up scenario was developed according to the current neighborhood planning information and the Town's Revised Municipal Development Plan (2009). Model results for the 1:100 year 24 hour Huff distribution and the historical City of Edmonton July 1937 storms confirmed that the older stormwater facilities in Town are unable to contain the 1:100 year storm runoff.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Valuable information for future development within the Town of Beaumont although no results regarding LeBlanc Canal channel capacity (which flows into Irvine Creek) were discussed. Release rate of 1.8 L/s/ha from development was adopted by the Town.			

**City of Edmonton, City of Leduc, Strathcona County
Leduc County, Town of Beaumont**

Ref #	Year	Title	Author
3.7	2009	Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 1	AMEC Earth & Environmental
Summary			
<p>This investigation provides a review of the existing studies along Whitemud/Blackmud Creek along with additional analyses to confirm that urbanization within the study basin contributes to an increase in in-stream erosion – beyond erosion expected under natural conditions. A flow duration frequency analysis was conducted to determine the impact of development on the streamflow regime. Through this analysis it was found that future development is expected to increase the duration and frequency of channel-forming streamflows, thus contributing to a net increase in erosive potential. A hydraulic model of the study reaches was constructed from available cross section and return period flow data to provide estimates on hydraulic parameters indicative of stream erosion potential. The model results strongly suggest a net increase in erosive potential downstream of developed areas, further supporting the assertion that urbanization contributes to increased erosion rates.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Model of study reach as well as outlined areas of erosion occurring.			

Ref #	Year	Title	Author
3.8	2008	Town of Beaumont LeBlanc Canal Hydraulic Performance Upgrading Analysis	Focus
Summary			
<p>The LeBlanc Canal traditionally served as an agricultural land drainage channel that is still under the jurisdiction of the County of Leduc. The purpose of the performance analysis is to evaluate the hydraulic capability of this drainage channel to serve the future needs of land development and the impact of development on flows within the channel outside the Town of Beaumont boundary to its connection at Irvine Creek. Field surveys were carried out to establish cross-sectional information and channel gradients between the culverts at the intermediate road crossings. Two conditions were modelled in the analysis; one being the existing channel with the removal of vegetation and establishment of uniform channel bottom gradients between culverts and the second being a widened channel again with a channel gradient between the fixed culverts. The results of the modelling indicate that the existing channel cross-section after cleaning and grading is adequate to convey the flows that will be generated by the proposed land development. The flows in the channel will be less attenuated and as a result somewhat greater peak flows will occur downstream in the section from Range Road 510 to Irvine Creek. The difference may not be noticeable especially in a major event when surface flooding occurs in this section due to the low banks in this section. Further study would be required to determine the impact of cleaning the canal on this area. Once the affects are further defined it is recommended that mitigation measures be designed to deal with any increase in predicted flooding.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
The LeBlanc Canal is tributary to Irvine Creek which in turn is tributary to Blackmud Creek.			

Ref #	Year	Title	Author
3.9	2007	Flood Level Determination for Blackmud Creek: NE 6-51-24-W4 Block B, SE 6-51-24-W4 Lot F	Sameng Inc.
Summary			
<p>The purpose of this study was to determine the flood levels along the Blackmud Creek within the studied properties, determine if the parcels of land could be filled on the west side of the creek to provide developable land that would not be flooded by a 1:100 year event, and to determine the impacts of such filling on the upstream properties. Sameng recommended a freeboard of 0.5 m be maintained above their estimated 1:100 year water levels with a sediment and erosion control program instituted.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Flood levels estimated with HEC-RAS model for Blackmud Creek within study area.			

Ref #	Year	Title	Author
3.10	2007	“East Vistas” Local Area Structure Plan NE ¼ 31-50-4-W4 100-Year Floodplain Study Irvine Creek	River Engineering Consulting
Summary			
<p>Delineation of floodway/flood fringe for approximately 1 km of Irvine Creek through NE ¼ 31-50-4-W4 (north of City of Leduc and west of Beaumont) with recommendations to reduce potential risk of damage to property, loss of human life, and identify the standards for the safe use of the lands. The 100-year flood level was calculated using a HEC-RAS model. It was concluded by River Engineering Consultants that there were no limitations on development from 100-Year floodplain limits as it is contained well within the valley surrounding Irvine Creek.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Hydraulic and morphological assessment of Irvine Creek through local area structure plan area.			

Ref #	Year	Title	Author
3.11	2005	Airport Road Watershed Study Final	Bel-MK Engineering Ltd.
Summary			
Watershed study for developments discharging to an unnamed tributary of Blackmud Creek north of Airport Road. The report defines the basin area boundaries for the tributary and identifies service basins in conjunction with their respective flows. Recommendations for monitoring water flow and quality are provided as well as identification of required upgrading for the tributary.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Development flows to the creeks identified.			

Ref #	Year	Title	Author
3.12	2005	Leduc County NE7 & NW 8-50-24-4 100-Year Flood Plain Study Blackmud Creek	River Engineering Consulting
Summary			
1:100 year floodway/flood fringe limits were mapped for approximately 700 m of Blackmud Creek through quarter sections NE 7 & NW 8-50-24-4 directly downstream of Saunders Lake for the 1:100 year flood. Blackmud Creek was channelized in 1983 to improve drainage and reduce flooding. Sameng Inc. completed a Blackmud Creek channel survey in 2004 and concluded that over the years the channel capacity has not significantly deteriorated. The 100-year flood levels were computed for a flood peak of 42.8m ³ /s downstream of the Clearwater confluence for Blackmud Creek using HEC-RAS and surveyed geometric data. Flood proofing for proposed development could be achieved by filling as the depth of filling is not large for the flood fringe according to River Engineering Consulting.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Annual maximum flow series and 100 year flood levels for Blackmud Creek.			

Ref #	Year	Title	Author
3.13	2004	Deer Creek 1:100 Years Floodplain Analysis in SE ¼ Sec. 33-49-25-4	Challenger Engineering
Summary			
<p>1:100 year floodplain analysis of approximately 1840 m of Deer Creek through the proposed Deer Valley subdivision (southwest area of City of Leduc SE ¼ 33-49-25-4) establishing the horizontal and vertical distance from the creek for environmental reserve and back of lot elevations. The following recommendations were made:</p> <ul style="list-style-type: none"> • All the lots must maintain a minimum distance of 6 m from the south creek bank • Lots to be graded such that the lowest opening of the building or back of lots be 600 mm higher than the 100 year flood level of the creek. • Area between the back of lots and the creek bank be dedicated as an Environmental Reserve. • Lots should have a maximum slope of 7:1 backing on to the Deer Creek environmental reserve 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
100 year flood levels through study area for Deer Creek tributary of Whitemud Creek			

Ref #	Year	Title	Author
3.14	2004	Nisku Industrial Business Park Design Flows Review	EXH Engineering Services Ltd.
Summary			
<p>This report addresses the need for a justified and consistent design flow estimate (including predevelopment maximum design flows) for the Nisku Industrial Business Park for Leduc County's Stormwater Management Plans which drains into the Blackmud Creek. Maximum pre development rate of 4.2 L/s/ha for the 1:100 year 24 hour storm is recommended to be accepted based on EXH Engineering Services Ltd. (2001) design flows which were verified based on maximum historical recorded Water Survey of Canada gauge stations and Alberta Transportation Bridge Files design information.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Pre and post development rates draining into Blackmud Creek basin.			

Ref #	Year	Title	Author
3.15	2001	Inter Municipal Drainage Study Whitemud Tributary Leduc County – City of Leduc	GPEC
Summary			
<p>This report presented a typical watershed plan for the Whitemud Tributary known as Deer Creek which was based on computer modelling of the watershed and Whitemud Tributary. The results of the model indicated that the channel provided an acceptable level of flood protection for existing land uses. The effects of urbanization were recommended to proceed in accordance with the Municipal Engineering Standards of the City of Leduc, Leduc County and the Stormwater Management Guidelines for the Province of Alberta, January 1999 and with using stormwater management facilities.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Watershed plan for Whitemud Creek tributary.			

Ref #	Year	Title	Author
3.16	2001	Inter Municipal Drainage Study on LeBlanc Canal	GPEC
Summary			
<p>GPEC conducted an inter-municipal drainage study on Leblanc Canal for the Town of Beaumont and Leduc County. Leblanc canal was constructed in 1910 and is located in the Town of Beaumont. The canal provides drainage for agricultural lands surrounding the Town, and the southwest, southeast and northwest quadrant of the Town. Ultimately the canal drains to Irvine Creek. Flooding occurs at locations along the length of the Canal during relatively minor rainfall events and significant flooding is experienced in moderate to heavy rainfall events. Stormwater runoff from the LeBlanc Drainage Basin, and the hydraulic capacity of the LeBlanc Canal and associated culverts were modeled with USEPA SWMM4. These flooding locations closely matched the flooding reported by the returned stakeholder questionnaires, as well as confirming other locations within the municipal boundaries. Minor channel improvements to remove blockages and restore the design capacity of the Canal were recommended, as well as the construction of stormwater management facilities and replacing depression storage.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Flows and drainage upstream of Irvine Creek tributary of Blackmud Creek.			

Ref #	Year	Title	Author
3.17	2001	Leduc County Nisku Industrial Business Park Storm Water Drainage Plan Preliminary Engineering Study	EXH Engineering Services Ltd.
Summary			
<p>This report outlines the results of storm water management analyses of the Nisku Industrial Business Park drainage basins into Blackmud Creek with a hydraulic model of the area. It was determined that for existing and future development the storm system capacity is adequately sized to accommodate the 1:5 year design storm event, except a few locations. The proposed improvements to the existing drainage facilities include installation of properly sized culverts, regrading of existing channels, and cleaning of debris and vegetation along the drainage channels. A long-term management policy is recommended to be implemented to restrict the runoff to an allowable release rate for each drainage basin and to store the runoff volume for a 1:100 year storm event.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Nisku runoff rates developed for 1:25 year 24 hour storm.			

Ref #	Year	Title	Author
3.18	1999	Whitemud Creek Watershed Plan Update Final Report	Cochrane Engineering
Summary			
<p>This report was an update to the 1983 Watershed Plan Study completed by ECOS Engineering Services Ltd. and recommends a maximum 1:100 year pre-development unit discharge rate of 5.0 L/s/ha from retention facilities. A key conclusion from the previous Watershed Plan Study was the effects of urban runoff with increased urbanization on existing drainage and the Creek systems. A continuous simulation analysis was completed. A detailed assessment of the downstream sections of the Whitemud and Blackmud Creeks, including a review of alternatives for rehabilitating actively eroding sites and bank instabilities was also recommended.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Watershed plan with pre-development release rate calculations.			

Ref #	Year	Title	Author
3.19	1991	Irvine Creek Water Management Project Including the LeBlanc Ditch and the Foley Lake Drainage System Preliminary Engineering Report	Samide Engineering Ltd.
Summary			
This report describes and makes recommendations concerning the proposed Irvine Creek Water Management Project located just north and east of the Town of Beaumont. Installation of drop structures, channel improvements, culverts, and control structures was recommended by Samide after using a HYMO model to simulate various floods on lake levels and outflows.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Tributary flows to Blackmud Creek.			

Ref #	Year	Title	Author
3.20	1985	Blackmud Creek Floodplain Study Saunders Lake to Highway 2	B.G. Bigornia, P. LaRocque
Summary			
This report outlines a study undertaken to determine the water surface profiles and flood risk areas along Blackmud Creek about 10 km between Saunders Lake and Highway 2. The flood risk areas to the west of the creek were delineated for the 1:100 and 1:25 year floods. The flood risk areas to the east of the creek were approximated by transferring the calculated water levels onto aerial photography. The 1:100 year floodplain was about 530 m wide from Saunders lake to the Boundary road bridge, where it was reduced to 290 m until the Canadian Pacific Railway grade. The average depth of flow in the floodplain was 1.8 m and the average velocity of floodplain flow was less than 0.1 m/s.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Historical floodplain delineation for Blackmud Creek.			

Ref #	Year	Title	Author
3.21	1983	Blackmud Creek and Irvine Creek Drainage Improvement Project	Stewart, Weir & Co.
Summary			
This report outlines the proposed drainage improvements of Blackmud and Irvine Creeks to reduce the frequency and duration of flooding. Approximately 4.5 km of Irvine Creek was recommended to be improved, along with increasing Blackmud Creek capacity. There was no capacity for additional discharge of water into Blackmud Creek without improvements.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Blackmud Creek and tributary flows.			

Ref #	Year	Title	Author
3.22	1983	City of Edmonton Watershed Plan Study for the Whitemud Creek Basin	ECOS Engineering Services Ltd.
Summary			
This watershed plan study identified the need for stormwater management and limiting the increase in runoff from urbanization to the Blackmud and Whitemud Creek basins.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Preliminary Whitemud Creek basin watershed plan for development to use as a basis for design.			

Ref #	Year	Title	Author
3.23	1981	Blackmud Creek Storage Channel	Stewart Weir et. al.
Summary			
Proposal of utilizing Blackmud Creek as a storm detention pond for the Nisku area. Stewart Weir et. al. concluded the use of Blackmud Creek as a storage channel was feasible and more economical than having storm ponds for each subdivision, and recommended detailed design of the concept.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Blackmud Creek flows circa 1981.			

Ref #	Year	Title	Author
3.24	1981	Nisku Stormwater Management Study	Associated Engineering Services Ltd.
Summary			
Objectives of this study were to expand and refine the drainage scheme along Highway 2 from the City of Leduc through Nisku, to provide recommendations to minimize erosion and maximize flood protection, and to verify the practicality of the drainage scheme proposed by Alberta Transportation.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Stormwater management plan for areas draining north towards Blackmud Creek.			

Hydrogeology Report Summaries

Ref #	Year	Title	Author
3.25	2014	The City of Edmonton Irvine Creek and Cawes Lake Watershed Study	Stantec
Summary			
<p>Watershed study for Irvine and Cawes Lake. The following conclusions and recommendations were relevant to hydrogeology:</p> <ul style="list-style-type: none"> • Surface and groundwater level monitoring to allow calibration and verification of SWMM modeling of Cawes Lake behaviour and available volume over time. • Groundwater quality and quantity of non saline water in the North Saskatchewan River should be protected and managed for consumption and other uses. • Stormwater management ponds can improve groundwater recharge, but care should be taken not to impact groundwater quality due to contaminated surface water introduction in the subsurface. • Riparian setbacks helps maintain the water quality in an aquatic system by lowering runoff velocity so that sediments can settle out of water and be deposited on land, by utilizing nutrients from groundwater which helps prevent eutrophication and by providing shade which helps reduce the water temperature. Native plants also protect shorelines by reducing bank erosion and failures that lead to sediment transport and potential loss of valuable lands. • It is therefore recommended that a hydrogeology study be completed in future to establish baseline conditions for the groundwater table in this watershed. A groundwater monitoring program should be conducted in order to track seasonal fluctuations in groundwater depth, as well as characterizing the water quality characteristics of the groundwater. Particular attention should be paid to groundwater contributions to Cawes Lake and Irvine Creek 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>A lack of groundwater monitoring and specific conceptual model for the study area could cause both quantity (erosion, reduction of recharge and baseflow) and quality issues for both surface water and groundwater due to future development. As groundwater and surface water resources are integrated, changing the conditions in the one will influence the other. Using existing water well information, ground truthing through a well audit program and adding this information into a 3D conceptual model can go a long way in management of these two Creek systems.</p>			

Ref #	Year	Title	Author
3.28	2013	Desktop Geotechnical Review, City of Leduc West of ASP Area NW & SW Quarters of Section 28-49-25-4 and Quarters of Section 28-49-25-4	CTA
Summary			
Brief information on hydrogeology in this report only gives estimates of groundwater levels between 3 and 6 m and very general lithology information. Basically till from surface to 6 m and up to 12 m below surface and bedrock shale below that. It is not anticipated that groundwater is locally recharged through the upper clays.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
No major influence on the management study apart from potential seepage zones at the local creeks if they are incised deep enough and potential channel bank erosion.			
3.29	2013	Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation.	Hardy Associates Ltd.
Summary			
Information on the status of groundwater in the two catchments. Findings from this is as follows: <ul style="list-style-type: none"> • The lithology in this small area of the overall project is basically comprised of fill and clay till down to 7 m, followed by clayey weathered shale. • Groundwater is shallow 2-3 m bgs within the Whitemud basin. • No other groundwater information was available. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Small footprint compared to the overall site and has little significance groundwater wise to the project. No other aquifer characteristics were available from this report.			

Ref #	Year	Title	Author
3.26	2009	Whitemud/Blackmud Creek Erosional Sites Characterization Study Stage 1.	Amec Earth and Environmental.
Summary			
Overview of studies reviewed and flow frequency analysis to determine impact from developments on streamflow regime based on in-stream erosion. No specific groundwater information included as part of the study just some remarks on potential erosional potential as a result of higher groundwater levels caused by new urban developments.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Groundwater increasing levels are mentioned as being other processes that could increase bank instability and cause erosion.			

Ref #	Year	Title	Author
3.27	1982	Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation.	Hardy Associates Ltd.
Summary			
<p>Information on the status of groundwater in the two catchments. Findings from this is as follows:</p> <ul style="list-style-type: none"> • Groundwater is shallow 2-3 m bgs within the Whitemud basin. • Shallower groundwater levels within 0.5 to 3 m bgs are evident in some areas. • Deeper groundwater levels were associated with the southern portions in Whitemud Creek. • Hydraulic permeability of the surficial glacial lacustrine clays is relatively low, in the order of 8.64E-03 to 8.64E-05 m/d, which is typically associated with clays. This means effectively recharge from precipitation will take much longer before reaching the deeper bedrock contacts. Areas with more surficial sandy material as opposed to clay will recharge at higher rates and cause seepages on bentonite and or bedrock contacts along the creeks. • Bedrock comprising sandstone and shale is evident along creek banks more so along the Whitemud Creek than the Blackmud Creek. • Slope failures are evident in a number of areas, which was reported in this report to occur along blocks 7-8 in the Whitemud Creek mainly. This seems to be associated with sandstone outcrops at the base with overlying sediments that are more permeable than the till clays. So it would seem that Blackmud Creek has more till clay above bedrock than the Whitemud area and hence Whitemud is more vulnerable to groundwater seepage and slope failures in turn causing erosional features. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Hydrogeologically it indicates the importance of aquifers and their relationship to specific lithological units. These units in turn will have connection to the two creeks and will impact baseflow to the creeks but also erosion levels. Seepage in more permeable units above bentonite or bedrock contacts in the creeks will have higher erosion associated with it. This is more evident in the Whitemud Creek than the Blackmud Creek.</p>			

3.30	1979	Hydrogeology of the Southwest Segment Edmonton Area, Alberta.	Research Council of Alberta.
Summary			
<p>The hydrogeology of the southwestern portion of Edmonton, explanation of aquifers, lithology, hydrogeological parameters etc. The map covers the major municipalities of Leduc, Millet, Calmar and Beaumont. The following information was evident from this report:</p> <ul style="list-style-type: none"> • During the time of the report only Millet and Calmar used groundwater, this might have changed but was not evident in any other reports reviewed. Judging by the amount of wells pre 1979 there was an increase in well drilling activity of 200 % in the Blackmud Creek catchment and 160 % in the Whitemud Creek catchment. • Groundwater flow regionally is mainly from southwest to the north towards the North Saskatchewan River; and north of the river it is southwards towards the river. There is some groundwater flow locally towards the Blackmud Creek, only where incisions are deep enough. • Recharge occurs mostly in the upland area adjacent to Pigeon Lake in the unconsolidated Quaternary sediments and deeper into the Paskapoo sandstone/siltstone formation. More permeable unconsolidated units (buried valleys) will also contribute to groundwater recharge, such as the quaternary sediments in between Woodbend and Golden Spike and also in the Millet area. • Recharge in the rest of the project area associated with the more clayey less permeable quaternary sediments will be fairly low. • Calcium-magnesium bicarbonate type groundwater dominates in the surficial deposits and sodium bicarbonate in the bedrock deposits. • Nitrate contamination is evident in the surficial drift sediments. • Deeper Paskapoo bedrock formations are the highest yielding aquifers in the area with up to 38 L/s, followed by the Horseshoe Canyon bedrock aquifer with up to 7.6 L/s. The clay till areas are mostly associated with well yields less than 2 L/s. • Groundwater levels range from 825 m amsl in the higher topographical areas to 700 m amsl in the Northern Saskatchewan River area where it discharges. No information is given on levels below ground surface in this report. • Only the southern most portion of the Whitemud Creek catchment would have potential issues with the Creek intercepting Paskapoo sandstones that could have high seepage rates into the Creek banks and cause erosion. The Southeastern section of the Blackmud Creek could intercept the Horseshoe Canyon Formation sandstone and bentonitic mudstone and Shale beds that could have seepage zones with slightly higher groundwater seepage flows causing erosional features. • The northern areas in both catchments will be associated with up to 15 to 30 m thick clayey till material with low permeability and less seepage issues. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Mostly higher permeable groundwater aquifer zones associated with the Paskapoo and Horseshoe Canyon sandstone / shale formations causing higher groundwater flow seepage zones along the Creeks that could cause erosional features or bank instabilities.</p>			

3.31	Continuously Updated, http://groundwater.alberta.ca/WaterWells/d/ accessed September 19, 2016.	Database where groundwater information can be sourced for specific areas from well lithological logs to help characterize aquifers for a geographical area	Alberta Environment and Parks.
Summary			
<p>Extracted well information from the AWWID for this report. There are 3776 records for the <u>Blackmud Creek area</u> and 1269 for the <u>Whitemud Creek area</u>.</p> <p>This information goes hand in hand with the above hydrogeological map information for the two catchment areas. The following additional information was sourced from the AWWID that could be relevant to the study they are discussed under each area as follows:</p> <p><u>Blackmud</u></p> <ul style="list-style-type: none"> • Average well depth is 50.76 m. • Average static groundwater level is 11.88 m below ground surface (m bgs), the well depth and water level indicates that the wells are likely established in the sandstone bedrock formations of the Horseshoe Canyon sandstones and to a lesser extent the Paskapoo sandstones. • The average well yield is 0.4 L/s indicating lower permeable aquifers typical of the bedrock aquifers. • The average screen depth of wells indicating the permeable aquifer sections is 45 m bgs. <p><u>Whitemud</u></p> <ul style="list-style-type: none"> • Average well depth is 49.26 m. • Average static groundwater level is 13.04 m bgs. • The average well yield is 0.5 L/s indicating lower permeable aquifers typical of the bedrock aquifers. • The average screen depth of wells indicating the permeable aquifer sections is 33.95 m bgs and likely established in the sandstone bedrock formations of the Paskapoo sandstones. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>From the above information it can be deduced that the till/drift clays in the Blackmud Creek catchment are likely thicker in the upper section with sandstone/shale bedrock situated below the upper clays. For the Whitemud Creek catchment results are similar however the upper till/drift material is not as thick and bedrock is likely closer to surface within the first 13 m bgs. The well information also indicates that the aquifers are not highly permeable. The fact that static water levels are deeper than the general clay layer thickness means that the clays are fairly impermeable and act as aquitards as opposed to aquifers, which means significant recharge is likely not occurring in these areas, which seems to cover most of the surface area of these two catchments. This means that increased pavement areas might not have such a severe impact on groundwater recharge in these areas.</p> <p>As there are minimal wells completed in the upper till/clay layers it is difficult to ascertain the groundwater table for the area, however seepage from this layer into stream banks at lithological</p>			

contacts are likely to be low flowing and can probably be mitigated with ease. It also indicates that deeper stream banks will likely intercept bedrock contacts in the Whitemud area to the south and to a lesser extent in the Blackmud areas to the south. It is also expected that these southern areas will contribute more to baseflow in the streams/creeks where the more permeable sandstone is in contact with the streams/creeks and lakes. This will have to be confirmed with stream gauging in different parts of the creeks through hydrograph separation techniques or potentially a more complex numerical groundwater model.

Environmental Report Summaries

Ref #	Year	Title	Author
3.32	2014	Environmentally Significant Areas in Alberta: 2014 Update	Fiera Biological Consulting
Summary			
<p>Areas identified as having high environmental significance were mapped and scored on a quarter section basis for different criteria including:</p> <ul style="list-style-type: none"> • Areas that contain focal species, species groups, or their habitats • Areas that contain rare, unique or focal habitat • Areas with ecological integrity • Areas that contribute to water quality and quantity 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Identifies significant areas that should be considered in land use decisions and watershed planning. The location of Environmentally Significant Areas within the study area provide useful information regarding ecological health and stressors and relate to management and protection priorities.</p>			

Ref #	Year	Title	Author
3.33	2001	Proposed Bridgeport Regional Shopping Centre Road Crossing of Deer Creek – Fish and Fish Habitat Assessment	Wentworth Associates Environmental Ltd.
Summary			
<p>A review of existing fisheries information for the Deer Creek was developed in support of a proposed road crossing. The study did not include field sampling was not possible because the creek was frozen, however existing information on the fisheries resource were provided.</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Fisheries resources will be reviewed for the study area at a high-level.</p>			

Ref #	Year	Title	Author
3.34	2015	Leduc County Environmentally Significant Areas Study	Fiera Biological Consulting
Summary			
Environmentally significant areas (ESA) were identified using ecological criteria specific to Leduc county providing more detailed evaluation than the provincial ESA study. As part of this study, up-to-date land cover and wetland inventory were developed.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
The presence of environmentally significant areas, land cover data, and wetland inventory data are important and relevant to the high level review for natural areas as they pertain to assessing ecological health and stressors and identifying protection priorities. Any spatial data available will be an important resource for the Blackmud/Whitemud Creek Surface Water Management Study			

Ref #	Year	Title	Author
3.35	2010	Telford Lake Master Plan: Biophysical Review of Sensitivities and Opportunities	Spencer Environmental Management Services Ltd.
Summary			
A biophysical review of Telford Lake was completed in support of a Master Plan. The Telford lake covers approximately 64 hectares and is a significant water body. Information on water quality, fish, vegetation, wetlands and other natural resources are described for the study area.			
The study was completed to guide the long-term protection and management of Telford Lake as a natural feature. As a part of the biophysical overview, baseline water quality data were collected for parameters including dissolved oxygen, pH, conductivity, turbidity, and temperature.			
<ul style="list-style-type: none"> • Water sampling was conducted on 3 occasions representing seasonal differences Generally, dissolved oxygen and other parameters were within guidelines. • Most water quality parameters did not exceed guidelines. • Appendix includes detailed water quality analysis of Telford Lake in April 2009 including metals, nutrients, hydrocarbons, routine water parameters. Only some exceedances for aluminum, chromium, cobalt, phosphorus, zinc, and chloride. 			
Expanded water quality monitoring program was recommended to further and accurately establish			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
The biophysical study for an important water body contributes to the understanding of aquatic resources and natural areas within the study area. Provides seasonal baseline water quality data for Telford Lake in 2009 including detailed water quality parameters.			

Ref #	Year	Title	Author
3.36	2012	Limited Phase I Environmental Site Assessment and Phase II Environmental Site Assessment Leduc Recreation Centre 4330 Black Gold Drive Leduc, AB	AMEC Environment and Infrastructure
Summary			
<p>Two surface water samples were collected from the stormwater management pond near 4330 Black Gold Drive Leduc, AB, in 2008 and 2011 and analyzed for routine potability, metals, cyanide, pH, and chloride parameters.</p> <ul style="list-style-type: none"> • Includes description of site location. • Results indicated that pH, aluminum, chromium, and phosphorus were above guidelines at that time. • Source of elevated metals had not been determined, further investigation was suggested. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Establishes historical surface water quality of the storm water pond in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized storm water inputs to creeks, tributaries, wetlands in the local area. Information also to used to guide the development of future monitoring plans, if recommended.</p>			

Ref #	Year	Title	Author
3.37	1982	Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation	Hardy Associates (1978) Ltd.
Summary			
<p>As a part of an Environmental Assessment for the Whitemud/Blackmud drainage basins, identified water quality in rural reaches, urban reaches, and identified potential pollution sources.</p> <ul style="list-style-type: none"> • Water quality in urban reaches increase in the number of chemical components (just above the confluence with the North Saskatchewan River). Evidence of deterioration. Exceedances: related phenols, chloride, phosphate, total dissolved solids, lead, manganese, fecal coliforms, and turbidity. Other heavy metals were within acceptable limits. • Noted that quality of water deteriorates as it passes through the basin to the confluence point with Blackmud Creek. through Includes description of site location. • Water quality in rural reaches generally did not exceed acceptable limits. Parameters include biochemical oxygen demand, total coliforms, chemical oxygen demand, chloride, orthophosphate, dissolved solids, total nitrogen and suspended solids. • Identified that a long term sampling program to identify the relationship between water quality and specific land use would be required. • Includes references for several studies carried out by various institutions that may be helpful for this Blackmud/Whitemud Creek Surface Water Management Study (e.g., Edmonton Water and Sanitation, University of Alberta Geography Department, Alberta Environment). • Potential pollution sources include sewage treatment plant in Leduc, sewage lagoons located at Edmonton International Airport, Beaumont and Nisku (sites that are monitored by Alberta Environment. Water quality associated with these discharges are described in this report. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Establishes historical surface water quality of the watersheds in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized discharges to creeks, tributaries, wetlands in the local area. Provides sources of information that should be investigated to yield more data. Information also to used to guide the development of future monitoring plans, if recommended.</p>			

**City of Edmonton, City of Leduc, Strathcona County
Leduc County, Town of Beaumont**

Ref #	Year	Title	Author
3.38	2015	Leduc County Environmentally Significant Areas Study	Fiera Biological Consulting
Summary			
Environmentally significant areas (ESA) were identified using ecological criteria specific to Leduc county providing more detailed evaluation than the provincial ESA study. As part of this study, up-to-date land cover and wetland inventory were developed.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
The presence of environmentally significant areas, land cover data, and wetland inventory data are important and relevant to the high level review for natural areas as they pertain to assessing ecological health and stressors and identifying protection priorities. Any spatial data available will be an important resource for the Blackmud/Whitemud Creek Surface Water Management Study			

Ref #	Year	Title	Author
3.39	2014	Irvine Creek and Cawes Lake Watershed Study	Stantec Consulting Ltd.
Summary			
Irvine Creek watershed includes lands within the Town of Beaumont, the City of Edmonton, Leduc County, and Strathcona County. The creek connects to Blackmud Creek upstream of 9 th street in Nisku. As a part of the watershed study completed for the City of Edmonton for Irvine Creek and Cawes Lake, the below information was provided.			
<ul style="list-style-type: none"> • Terrestrial resources including vegetation communities, wetlands and wildlife • Aquatic resources including fish, fish habitat and benthic invertebrates • Baseline water quality sampling was completed for three sites along Irvine Creek and included field measurements of pH, conductivity, temperature, turbidity, and dissolved oxygen. Data are provided in a table and generally, dissolved oxygen and other parameters were within guidelines. • Expanded water quality monitoring program was recommended to further and accurately establish baseline water quality conditions. Parameters include: dissolved oxygen total suspended solids, total dissolved solids, total coliforms, and oil and grease. • Appendix A was provided. However other appendices associated with this report are missing and would be of value to the Blackmud/Whitemud Creek Surface Water Management Study. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
This study identified and mapped terrestrial and aquatic resources, which will be a useful reference when compiling similar data for natural resources within the Blackmud and Whitemud Creek basins. Provides baseline water quality data for Irvine Creek. Provides sources of information that should be investigated to yield more data. Information also to be used to guide the development of future monitoring plans, if recommended.			

Ref #	Year	Title	Author
3.40	2014	Environmentally Significant Areas in Alberta: 2014 Update	Fiera Biological Consulting
Summary			
<p>Areas identified as having high environmental significance were mapped and scored on a quarter section basis for different criteria including:</p> <ul style="list-style-type: none"> • Areas that contain focal species, species groups, or their habitats • Areas that contain rare, unique or focal habitat • Areas with ecological integrity • Areas that contribute to water quality and quantity 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Identifies significant areas that should be considered in land use decisions and watershed planning. The location of Environmentally Significant Areas within the study area provide useful information regarding ecological health and stressors and relate to management and protection priorities.</p>			

Ref #	Year	Title	Author
3.41	2014	Irvine Creek and Cawes Lake Watershed Study	Stantec Consulting Ltd.
Summary			
<p>As a part of the watershed study completed for the City of Edmonton for Irvine Creek and Cawes Lake located in the northeastern corner of Leduc County, south of the City of Edmonton and east of Highway 2. Irvine Creek watershed includes lands within the Town of Beaumont, the City of Edmonton, Leduc County, and Strathcona County. The creek connects to Blackmud Creek upstream of 9th street in Nisku.</p> <ul style="list-style-type: none"> • Baseline water quality sampling was completed from three sites along Irvine Creek and included field measurements of pH, conductivity, temperature, turbidity, and dissolved oxygen. Data are provided in a table. • Generally, dissolved oxygen and other parameters were within guidelines. • Expanded water quality monitoring program was recommended to further and accurately establish baseline water quality conditions. Parameters include: dissolved oxygen total suspended solids, total dissolved solids, total coliforms, and oil and grease. • Appendices associated with this report are missing and would be of value to the Blackmud/Whitemud Creek Surface Water Management Study. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Provides baseline water quality data for Irvine Creek. Provides sources of information that should be investigated to yield more data. Information also to be used to guide the development of future monitoring plans, if recommended.</p>			

**City of Edmonton, City of Leduc, Strathcona County
Leduc County, Town of Beaumont**

Ref #	Year	Title	Author
3.42	2012	Limited Phase I Environmental Site Assessment and Phase II Environmental Site Assessment Leduc Recreation Centre 4330 Black Gold Drive Leduc, AB	AMEC Environment and Infrastructure
Summary			
<p>Two surface water samples were collected from the stormwater management pond near 4330 Black Gold Drive Leduc, AB, in 2008 and 2011 and analyzed for routine potability, metals, cyanide, pH, and chloride parameters.</p> <ul style="list-style-type: none"> • Includes description of site location. • Results indicated that pH, aluminum, chromium, and phosphorus were above guidelines at that time. • Source of elevated metals had not been determined, further investigation was suggested. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>Establishes historical surface water quality of the storm water pond in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized storm water inputs to creeks, tributaries, wetlands in the local area. Information also to used to guide the development of future monitoring plans, if recommended.</p>			

Ref #	Year	Title	Author
3.43	2010	Telford Lake Master Plan: Biophysical Review of Sensitivities and Opportunities	Spencer Environmental Management Services Ltd.
Summary			
<p>A biophysical review of Telford Lake was completed in support of a Master Plan. The Telford lake covers approximately 64 hectares and is a significant water body. Information on water quality, fish, vegetation, wetlands and other natural resources are described for the study area. The study was completed to guide the long-term protection and management of Telford Lake as a natural feature. As a part of the biophysical overview, baseline water quality data were collected for parameters including dissolved oxygen, pH, conductivity, turbidity, and temperature.</p> <ul style="list-style-type: none"> • Water sampling was conducted on 3 occasions representing seasonal differences Generally, dissolved oxygen and other parameters were within guidelines. • Most water quality parameters did not exceed guidelines. • Appendix includes detailed water quality analysis of Telford Lake in April 2009 including metals, nutrients, hydrocarbons, routine water parameters. Only some exceedances for aluminum, chromium, cobalt, phosphorus, zinc, and chloride. <p>Expanded water quality monitoring program was recommended to further and accurately establish</p>			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
<p>The biophysical study for an important water body contributes to the understanding of aquatic resources and natural areas within the study area. Provides seasonal baseline water quality data for Telford Lake in 2009 including detailed water quality parameters.</p>			

Ref #	Year	Title	Author
3.44	2001	Proposed Bridgeport Regional Shopping Centre Road Crossing of Deer Creek – Fish and Fish Habitat Assessment	Wentworth Associates Environmental Ltd.
Summary			
A review of existing fisheries information for the Deer Creek was developed in support of a proposed road crossing. The study did not include field sampling was not possible because the creek was frozen, however existing information on the fisheries resource were provided.			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Fisheries resources will be reviewed for the study area at a high-level.			

Ref #	Year	Title	Author
3.45	1982	Watershed Plan for Whitemud and Blackmud Creeks Geotechnical and Environmental Evaluation	Hardy Associates (1978) Ltd.
Summary			
As a part of an Environmental Assessment for the Whitemud/Blackmud drainage basins, identified water quality in rural reaches, urban reaches, and identified potential pollution sources.			
<ul style="list-style-type: none"> • Water quality in urban reaches increase in the number of chemical components (just above the confluence with the North Saskatchewan River). Evidence of deterioration. Exceedances: related phenols, chloride, phosphate, total dissolved solids, lead, manganese, fecal coliforms, and turbidity. Other heavy metals were within acceptable limits. • Noted that quality of water deteriorates as it passes through the basin to the confluence point with Blackmud Creek. through Includes description of site location. • Water quality in rural reaches generally did not exceed acceptable limits. Parameters include biochemical oxygen demand, total coliforms, chemical oxygen demand, chloride, orthophosphate, dissolved solids, total nitrogen and suspended solids. • Identified that a long term sampling program to identify the relationship between water quality and specific land use would be required. • Includes references for several studies carried out by various institutions that may be helpful for this Blackmud/Whitemud Creek Surface Water Management Study (e.g., Edmonton Water and Sanitation, University of Alberta Geography Department, Alberta Environment). • Potential pollution sources include sewage treatment plant in Leduc, sewage lagoons located at Edmonton International Airport, Beaumont and Nisku (sites that are monitored by Alberta Environment. Water quality associated with these discharges are described in this report. 			
Impact to Blackmud/Whitemud Creek Surface Water Management Study			
Establishes historical surface water quality of the watersheds in the vicinity of Leduc Alberta. This information may be used to identify potential impact to the watershed from localized discharges to creeks, tributaries, wetlands in the local area. Provides sources of information that should be investigated to yield more data. Information also to used to guide the development of future monitoring plans, if recommended.			