APPENDIX A
Summary of AEP/AER Meeting October 4, 2018
(Task 2)

MEMORANDUM

TO: Mike De Luca, PTAC (Industry Technical Champion)

FROM: William Wilmot, Hugh Abercrombie, and Ron Coutts, Matrix Solutions Inc.

SUBJECT: Summary of AEP/AER Meeting October 4, 2018 (WIPC 1801)

DATE: October 15, 2018

1 BACKGROUND

Task 2 of the WIPC 1801 Project entitled *Develop Definitions for Alternative Water Sources to High Quality Non-saline Groundwater* required Matrix to meet with the Alberta Environment and Parks (AEP) and Alberta Energy Regulator (AER) to address the following objectives:

i. Review project scope with AEP/AER

ii. Review work already completed by AEP/AER relevant to the Project

2 ALBERTA ENVIRONMENT AND PARKS/ALBERTA ENERGY REGULATOR MEETING

The meeting with AEP/AER was held on October 4, 2018 at the Matrix Calgary office. The following people were present at the three hour meeting:

- Steve Wallace (AEP)
- Michelle Morris (AEP)
- Joelle MacDonald (AER)
- Michael Bevan (AER)
- Brent Welsh (AER)
- Nino Aimo (AER)
- Pat Marriott (AER)
- Brian Smerdon (AGS[1])
- Mike De Luca (PTAC)
- Bill Wilmot (Matrix)
- Hugh Abercrombie (Matrix)
- Ron Coutts (Matrix)

[1] Alberta Geological Survey

3 ALTERNATIVES TO HIGH QUALITY NON-SALINE WATER

Five alternatives to high quality non-saline water are presented in the draft AEP document entitled *Water Conservation Policy for Upstream Oil and Gas Operations* (AEP 2016) as follows:

a) recycled or reconditioned industrial and municipal wastewater, taking return flows into perspective

b) oil sands mining tailings pond water

c) non-saline water in direct contact with bitumen deposits

d) naturally occurring non-saline water containing petroleum hydrocarbon compounds (excluding methane) within formations that contain both water and hydrocarbon resources

e) non-saline groundwater that is demonstrated to be economically and technologically impractical to use for drinking water or livestock watering purposes, taking into consideration the local hydrogeological setting, as it pertains to hydraulic connectivity in support of instream and aquatic ecosystem needs and availability of other water supplies for existing or potential water users in the area

During this meeting, alternatives (a) and (b) were not discussed. There were brief discussions concerning alternatives (c) and (d). The discussions generally centred on alternative (e).

4 PROCEDURES

4.1 Project Scope

In an effort to be transparent and collectively progress forward, the Project scope was presented to all in attendance. Bill Wilmot (Matrix) delivered a presentation briefing the participants on the background, objectives, tasks, and status of the Project, with some recommendations for next steps.

4.2 Work Completed

Most of the meeting was an open discussion between AEP, AER, and AGS regarding topics of water definitions, regulatory documents, work completed, work contemplated, subsectors, and other jurisdictions.

4.2.1 Other Jurisdictions

The jurisdictions and resources listed below have been contemplated by AEP and AER for various purposes of water management. Nonetheless, it was discussed during the meeting that no jurisdiction listed below has played a large role in policy guidance or implementation.

- Saskatchewan
- British Columbia

- Manitoba
- Ontario
- New Brunswick
- Australia (informed Alberta *Water Act*)
- USA

    - US Environmental Protection Agency concept of aquifer exemption clause or industrial use aquifer (GPO 2018)
    - Texas, Wyoming, Kansas, and California in particular
    - Rosenberg Forum (International Panel of Experts and public document; Rosenberg 2007)

5 KEY FINDINGS

Based on the meeting, Matrix identified the following key learnings from each organization:

5.1 Alberta Environment and Parks

- Compared to the 2006 oilfield injection policy (AEP 2016), one of the policy objectives of the 2016 draft was to place more emphasis on developing ways of licencing alternatives to non-saline groundwater.

- AEP developed the definition of alternative sources for non-saline groundwater that are technologically or economically impractical, (Point (e), Section 3.0 above). During multi-stakeholder engagement meetings, AEP attempted to develop a more specific definition, but were unable to reach an agreeable consensus within the time available.

- AEP currently has no intention of re-opening stakeholder engagement on this point and is unlikely to bring a revised definition of Point (e), Section 3.0 above, into Policy. Any refinement of this definition would be done by AER as part of regulatory implementation in the form of guidelines, directives, or interpretive bulletins. The current policy language is a placeholder for AER.

- AEP reiterated the importance of the qualifying statements in Point (e), Section 3.0 above (i.e., requirements for sufficient base-flow support to critical receptors, as well as the reality of competition amongst limited aquifer options).

- AEP wishes to avoid describing alternative non-saline water as “low-quality” because this term is subjective. Non-saline water that is low-quality to some stakeholders may be good or high quality to other stakeholders.

- AEP discussed their recent Directive for Water Licensing of Hydraulic Fracturing Projects – Area of Use Approach (AEP 2018). The document illustrates AEP’s recognition of unique circumstances of certain sub-sectors and geographic areas.

5.2 Alberta Energy Regulator

- AER suggested that it may be best to approach this issue from an intrinsic "value of water" perspective (similar to the relative value concept presented in Wetland Policy). In other words, waters of the same quality (chemistry basis) in different geographic areas may have different intrinsic value based on water availability in those geographic areas. This approach is based on the abundance or scarcity of water. As such, water quality alone may be an improper differentiator with respect to Point (e), Section 3 above. Therefore using the drinking water guidelines approach can be fraught with pitfalls.

- With respect to Point (e), Section 3 above, "economically" and "technologically" refer more to water access than to water treatment. Water treatment technology is continually improving and becoming increasingly cost effective.

- AER stressed the importance of Quaternary aquifers, their degree of connection to surface water bodies, and their presence in water short areas. An aquifer depth of more than 150 m is usually considered a useful criterion in terms of feasibility, connectedness, and lesser competition with other users. Very few existing domestic/stock water wells in the Alberta Groundwater Well Database are deeper than 150 m below ground surface.

- AER is developing a preliminary implementation strategy for wording provided in Directive 081 and the draft Water Conservation Policy. Implementation criterion includes (i) greater than 150 m depth, (ii) connectedness to/of Quaternary aquifers, and (iii) water short regions.

- AER wants to ensure that operators will not be incentivized to abandon saline water sources for alternative non-saline sources as a result of refined non-saline water source definitions.

- AER reiterated that they do not intend to change existing directives based on new definitions (i.e., casing depths, cementing disposal). For example, wastewater disposal in a non-saline geologic unit will continue to be unacceptable regardless of whether or not the groundwater within the geologic unit is considered to be an alternative to non-saline water.

5.3 Alberta Geological Survey

- AGS has ongoing tasks to define groundwater availability at depths shallower than 150 m and to conduct salinity mapping in regards to the boundary between saline and non-saline groundwater.

- AGS has discussed defining "hydrogeological provinces" with other parties in government; however, a potential issue with these efforts is the development of yet another governance boundary (shape) that overlaps with other governance boundaries such as river basins, municipalities, etc.

5.4 Matrix Solutions Inc.

- Most regulatory attendees were accepting of Matrix's concepts of:

    - Decision tree when determining technological and economic feasibility of an alternative groundwater source Points (e), Section 3.0 above – a logical sequencing of decision points that will accept or exclude a groundwater source as alternative.

- Geographic control – hydrogeological setting is crucial to managing groundwater resources given large hydrogeological variability across the Province.

- Risk-based management approach – a groundwater management approach that prioritizes groundwater based on risk.

- Defined petroleum hydrocarbon cut-offs with respect to Points (c) and (d), Section 3.0 above.

CLOSURE

This document summarizes the key findings from the October 4 meeting with AEP and AER to discuss work already completed by these organizations that are relevant to the Project's objectives. The key findings from this meeting provide Matrix with important context when completing the next Project task (Task 3). Task 3 is to complete a regulatory review of Alberta and other jurisdictions (North America and Internationally) to compare definitions of (1) the difference between non-saline and saline water; (2) groundwater that is technologically and economically impractical to use for drinking water supplies or livestock watering; and (3) alternatives to non-saline/fresh water. Task 3 will be summarized in a subsequent memorandum and reviewed with the WIPC project champion (Task 4). Task 5 will be to organize a meeting with industry representatives that is similar in scope to the meeting discussed above.

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APPENDIX B
Jurisdictional Water Management Review
(Tasks 1, 3, and 4)

MEMORANDUM

TO: Mike De Luca, PTAC (Industry Technical Champion)

FROM: William Wilmot, Hugh Abercrombie, and Ron Coutts, Matrix Solutions Inc.

SUBJECT: Jurisdictional Water Management Review (WIPC 1801)

DATE: October 25, 2018

1 BACKGROUND

The WIPC 1801 Project entitled *Develop Definitions for Alternative Water Sources to High Quality Non-saline Groundwater* required Matrix Solutions Inc. to complete the following eight tasks:

- Task 1: Review draft policy entitled *Water Conservation Policy for Upstream Oil and Gas Operations*.
- Task 2: Meet with Alberta Environment and Parks (AEP) and the Alberta Energy Regulator (AER) to review scope and work already completed.
- **Task 3: complete a regulatory review of Alberta and other jurisdictions (North America and Internationally) to compare definitions of (1) the difference between non-saline and saline water; (2) groundwater that is technologically and economically impractical to use for drinking water supplies or livestock watering; and (3) alternatives to non-saline/fresh water.**
- Task 4: Tabulate this information and review with the WIPC project champion.
- Task 5: Incorporate industry experience and make recommendations to meet project objectives.
- Task 6: Review recommendations with AEP and AER and adjust as necessary.
- Task 7: Prepare concise summary report for WIPC review.
- Task 8: Incorporate WIPC edits and present report to PTAC.

The objective of this document is to summarize Task 3 in order to facilitate Task 4 above.

2 METHODS

Note Task 2 (AEP/AEP meeting) listed above, frames the context of Task 3 (Jurisdictional review). Task 2 which is summarized in a separate memorandum included, but were not limited to, the following topics of discussion:

- Relevant Alberta policy, regulations, guidelines and documents
- Relevant Alberta definitions
- Jurisdictions and non-Alberta documents that influenced Alberta policy or guidelines

Task 2 formed the basis for the information presented in the remainder of this document. This jurisdictional water management review was mostly conducted in the context of non-saline groundwater that is economically and technologically impractical for drinking water purposes.

3 ALBERTA

Relevant Alberta documents that were reviewed are summarized on Table 1. Groundwater definitions from Matrix's regulatory review of Alberta are summarized on Table 2.

Salient points from Alberta documents and definitions include:

- The goals of Alberta's *Water for Life Strategy* (GoA 2003) are; healthy aquatic ecosystems; safe, secure drinking water; and reliable, quality water supplies for a sustainable economy.
- Non-saline groundwater is specified to have less than 4,000 mg/L total dissolved solids (TDS) (Province of Alberta 2017). This is sometimes referred to as usable groundwater and fresh groundwater.
- High quality groundwater is defined in the context of waterworks systems and is defined as groundwater of drinking water quality that is not in direct influence of surface water (AENV 2009).
- Aquifers connected to surface water, or shallow groundwater, are considered higher risk aquifers.
- Domestic use aquifers are defined based on groundwater quantity rather than quality.
- Base of Groundwater Protection varies in depth across the Province but its maximum depth has a default of 600 m below ground surface (bgs; EUB 2007).
- The depth of 150 m bgs as a key threshold with AER. Complying with AER regulations beyond this depth is costly and logistically challenging.
- The concepts of risk-based approach, adaptive management and priority management are demonstrated in various documents, most notably via Aquifer Management Units and Groundwater Management Units.
- The concepts of regional differences and specific management strategies are demonstrated in various documents (i.e., Land Use Framework, water short areas, green areas, etc.).
- The acknowledgement of oil and gas sub-sector differences that may require specialized management. Subsectors identified include; oil sands mining operations, oil sands thermal in situ operations, enhanced oil recovery and multi-stage hydraulic fracturing operations. For example the

Point of Use Directive for hydraulic fracturing acknowledges the unique challenges of water use for multi-stage hydraulic fracturing operations (AEP 2018).

- Alberta Environment retained AMEC Earth & Environmental to conduct a cost-benefit analysis of treating saline groundwater in 2007 (AMEC 2007). As part of this study AMEC researched groundwater regulations and conducted interviews with representatives from other jurisdictions.

4 OTHER JURISDICTIONS

Jurisdictions and related documents mentioned during Task 2 included:

- British Columbia
- Saskatchewan
- Manitoba
- Ontario
- New Brunswick
- United States of America
    - United States Environmental Protection Agency
    - California
    - Kansas
    - Texas
    - Wyoming
- Australia
- Rosenberg International Forum on Water Policy to the Ministry of Environment, Province of Alberta (February 2007).

4.1 British Columbia

- Usable groundwater is defined as groundwater up to 4,000 mg/L TDS (the Commission 2016).
- Deep groundwater, (i.e., groundwater below 600 mbgs), can be shallower in subject area based on geology (the Commission 2016).
- Base of Usable Groundwater is area specific (e.g., northeast BC), with minimum and maximum depths of 300 and 600 m bgs, respectively (the Commission 2016).

4.2 Saskatchewan

- A potable water aquifer is defined as a hydrostratigraphic unit that has a bulk hydraulic conductivity of 1×10^{-6} m/s or greater, has sufficient thickness to support a sustained yield of 0.76 L/min for 20 years, and does not contain chemical constituents that make the water unsafe for human consumption or contain constituents that render the water aesthetically undesirable if those constituents cannot be removed (Saskatchewan ENV 2014).

- Fresh water is defined as having TDS concentrations of less than 4,000 mg/L (Province of Saskatchewan 2012).

4.3 Manitoba

- An aquifer management zone is designated as a geographic area containing one or more aquifers or portions of aquifers (Province of Manitoba 2012).

- An aquifer planning authority is appointed for an aquifer management zone and submits and aquifer management plan (Province of Manitoba 2012).

- Saline groundwater is defined in the Groundwater and Water Well Act as groundwater that meets prescribed criteria in regulations (Province of Manitoba 2012). Saline water has a concentration in excess of 3,500 mg/L TDS (Province of Manitoba 2017).

4.4 Ontario

- Fresh groundwater contains less than 1,000 mg/L TDS; brackish groundwater contains 1,000 to 10,000 mg/L TDS; saline groundwater contains 10,000 to 100,000 mg/L TDS; and brine contains greater than 100,000 mg/L (Carter et al. 2014).

4.5 New Brunswick

- Non-saline groundwater contains less than 4,000 mg/L TDS (NBNGG 2013).

4.6 United States of America

4.6.1 US Environmental Protection Agency

- An Underground Source of Drinking Water (USDW) is defined as an aquifer that supplies a public water system, or contains sufficient quantity of groundwater to supply a public water system, and currently supplies drinking water for human consumption, or contains fewer than 10,000 mg/L TDS (GPO 2018a).

- The Underground Injection Control (UIC) regulations allow the EPA to exempt USDW that will not serve as a source of drinking water in the future based on certain criteria (GPO 2018b). These USDWs are referred to as “exempted aquifers.” Conditions include:

    - does not currently serve as a source of drinking water
    - the aquifer cannot now and will not in the future serve as a source of drinking water because:

        - it is mineral, hydrocarbon or geothermal producing, or can be demonstrated to be commercial producible

        - it is situated at a depth or location which renders the recovery of water for drinking water purposes economically or technologically impractical. Impracticality is determined by:

- availability of less costly and more readily available supplies
- adequacy of alternatives to meet present and future needs
- cost of treatment and development associated with use of the aquifer
- economic evaluation which should consider the distance of the proposed exempted aquifer to public water supplies, the water supply of potential users of the exempted aquifer, the availability (quantity/quality) of alternative water supply sources, the analysis of future water supply needs within a general area, the depth of proposed exempted aquifer and the quality of the water in the proposed exempted aquifer.
    - it is so contaminated that it would be economically or technologically impractical to render the water fit for human consumption
    - it is located over a well mining area subject to subsidence or catastrophic collapse
- the TDS content of groundwater is more than 3,000 and less than 10,000 mg/L

- Energy and mining companies are allowed to use exempted aquifers for oil or mineral extraction or disposal purposes in compliance with EPA's UIC requirements under the *Safe Drinking Water Act*.

4.6.2 California

- California Sustainable Groundwater Management Act recognizes the importance of regional differences and local management (State of California 2014).

4.6.3 Kansas

- Groundwater Management Districts created for, among other things, the proper management of the groundwater resources of the state; for the conservation of groundwater resources; and for the prevention of economic deterioration (State of Kansas 2018).

- Kansas Geological survey defines fresh groundwater as less than 1,000 mg/L TDS and brine as greater than 10,000 mg/L TDS (Buchanan and Buddemeier 1993).

4.6.4 Texas

- Groundwater conservation districts are empowered and charged to conserve, preserve, protect, recharge, and prevent waste of groundwater resources within their boundaries (State of Texas 2005). Groundwater conservation districts follow hydrogeology and political boundaries. Groundwater conservation districts are the state's preferred method of groundwater management.

4.6.5 Wyoming

- Wyoming provides groundwater classifications for domestic, agricultural, livestock, aquatic life and industry use based on groundwater quality (State of Wyoming 2005). Class VI is groundwater that is

not suitable for use by standards of contamination (other than TDS) or located in such a way, including depth below surface, to make use economically and technologically impractical. Economically and technologically impractical are not specifically defined.

- Groundwater Control Areas and respective Advisory Boards advise and assist the State Engineer and Board Control on formulating policies and recommendations on applications and petitions concerning groundwater development in the Control Area (Jacobs et al. 2003).

4.7 Australia

- Groundwater is managed at the local scale. Development of area specific groundwater management plans requires understanding of geology, hydrogeological settings, hydrodynamics, environmental water requirements, and water use practices (present and future). Australia has a strategy of risk-based categorization of high priority groundwater resources (Australian Government 2016).

- In Victoria, groundwater is categorized in terms of beneficial use and measured in TDS. Acceptable potable water supply is less than 1,500 mg/L TDS (Victoria Government Gazette 1997).

4.8 Rosenberg International Forum (Alberta Workshop)

A workshop was convened at the request of the Minister of the Environment, Province of Alberta, Canada (Rosenberg 2007). The workshop consisted of a panel of distinguished experts. The panel was first asked to "review the *Alberta Water Strategy, Water for Life*, and make some recommendations as to how it could be strengthened both as a strategic document and in the implementation of various measures that make up that strategy." Second, "in recognition of the increasing importance of groundwater in Alberta's water budget, the panel was asked to review the existing arrangements for governing and managing groundwater in the Province and make recommendations about how those arrangements could be further strengthened and improved." Several recommendations were submitted, including the two below which provide context to the objectives of this memorandum:

- **Recommendation 1**:
    - *"Water of quality in the 4,000 to 10,000 total dissolved solids range has considerable value as a resource after treatment. Therefore, the definition of groundwater resource should be extended to include this quality range."*

- **Recommendation 2**:
    - *"The Water Planning and Advisory Councils, as currently structured, align with surface water watersheds, which are not always coincident with aquifers. Groundwater management institutions need to be spatially aligned with the realities of aquifer dynamics."*

5 CONCLUSIONS

Based on the aforementioned objectives of this jurisdictional review, the following conclusions are supported:

(1) Regarding the difference between non-saline and saline water it is concluded that not all jurisdictions formally define the difference between non-saline and saline groundwater. In Canada, 4,000 m/L TDS is generally the accepted threshold. Elsewhere, 10,000 mg/L seems to be a more typical threshold. The Rosenberg Forum specifically recommended that Alberta increase the non-saline definition to 10,000 mg/L.

(2) The USEPA and State of Wyoming include the phase "economically and technologically impractical" in the context of groundwater use, however, neither body explicitly or comprehensively defines thresholds for either. Wyoming does classify groundwater for use based on groundwater quality thresholds but the closest analogy reviewed (based on objectives of this project) is from the United States Environmental Protection Agency's (USEPA) aquifer exemption conditions. Parameters used by the USEPA to determine "impracticality" include; consideration that the aquifer is currently being used for drinking water; the availability of less costly and more readily available drinking water aquifers and adequacy of those drinking water aquifers; the cost of treatment and development of an impractical aquifer; the distance to public water supplies; the water supply of potential users of exempted aquifer; the availability (quantity and quality) of alternative water supply sources; the analysis of future water supply needs within a general area; the depth of proposed exempted aquifer; and the quality of the water in the proposed exempted aquifer.

(3) Regarding alternatives to non-saline/fresh water, it was concluded that four alternatives to non-saline or fresh water were mentioned in addition to what is already documented in the draft AEP *Water Conservation Policy for Upstream Oil and Gas Operations (draft)*. All four of the alternatives originate from the USEPA's criteria for aquifer exemption, most of which are not believed to be particularly relevant in Alberta. The four alternatives are; an aquifer that is geothermal energy producing, an aquifer that is mineral producing, an aquifer that is contaminated such that it could never be rendered fit for human consumption, and an aquifer located over a well mining area subject to subsidence and collapse.

6 RECOMMENDATIONS

Based on the conclusions presented above, the following key recommendations regarding alternative sources to high quality non-saline groundwater are proposed:

- Using TDS as a threshold indicator of an alternative source to high quality non-saline groundwater should not be pursued. As mentioned in the Rosenberg Forum, water treatment of 4,000 to 10,000 mg/L TDS waters may have considerable value in geographic areas where this is the only groundwater quality available for domestic or livestock use.

- Developing hydrocarbon thresholds to determine if an aquifer is in direct contact with bitumen deposits or is a naturally occurring non-saline groundwater aquifer containing petroleum hydrocarbons, (excluding methane), is worth further consideration. Groundwater with naturally elevated dissolved hydrocarbon is unlikely to be considered a priority drinking water supply in the foreseeable future.

- Developing a management approach that takes into consideration the regional uniqueness of the hydrogeological regime is crucial to effective groundwater management. This approach is undertaken in many jurisdictions (Manitoba, Texas, California, Wyoming, Kansas, and Australia) and

was recommended by the Rosenberg Forum. The concept of groundwater management based on regional uniqueness or individual aquifers is recognized in Alberta.

- Developing a depth threshold to determine if groundwater is technologically and economically impractical to source should be considered. Depth thresholds will likely vary regionally, and "connectedness" to surface water should be assessed. Consideration of the hydrogeologic setting and water users are paramount. Aquifer depth is currently used as a threshold in Alberta and British Columbia to determine base of usable non-saline groundwater.

- Developing a workable definition of non-saline groundwater that is technologically and economically impractical to use for drinking water or livestock water purposes is synonymous with defining a low-risk or low-priority non-saline aquifer. The corollary is that non-saline aquifers that do not meet that definition are high-risk or high priority aquifers. It would follow that high-risk, high priority aquifers would be managed with commensurate rigour.

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TABLE 1 Relevant Alberta Documents

Type	Document	Relevance
Overarching Documents	Water for Life: Alberta's Strategy for Sustainability (GoA 2003)	Non-saline water defined as water with TDS less than 4,000 mg/L
	Water Act Revised Statutes of Alberta (Province of Alberta 2017)	Non-saline water defined as water with TDS less than 4,000 mg/L
	Water (Ministerial) Regulation (Province of Alberta 1998)	Non-saline water defined as water with TDS less than 4,000 mg/L
	Land-use Framework an associated regional plans (Province of Alberta 2008)	Developing and implementing a land-use system that will effectively balance competing economic, environmental and social demands. It sets out an approach to manage public and private lands and natural resources to acheive Alberta's long-term economic, environmental and social goals. The purpose of the Land-Use Framework is to manage growth, not stop it.
	Water Conservation Policy for Upstream Oil and Gas Operations (Drafts) (AEP 2016)	Specific water policy and direction for oil sands mining operations oil sands thermal in situ operations, enhanced oil recovery (water flooding) and multi-stage hydraulic fracturing operations in horizontals wells. Includes improvements in water use data management and reporting. Objective of the policy is the preferred use of saline groundwater or alternative sources. The policy will apply to all areas of the province where the Water Act is administrated over upstream oil and gas operations. Document recognizes that some sources of non-saline groundwater and surface water with low water quality are environmentally preferable for upstream oil and gas operations relative to the use of high quality groundwater. Acknowledges that non saline water in direct contact with bitumen deposits and naturally occurring non saline water containing petroleum hydrocarbon compounds excluding methane within formation that contain both water hydrocarbon resources and non saline groundwater that is demonstarted to be economically and technologically impractical to use for drinking water or livestock water purposes taking into consideration the local hydrogeology setting as it pertain to hydraulic connectivity in support of instream and aquatic ecosystem needs and availability of other water supplies for existing or potential water users in the area. Criteria for defining non saline groundwater that is economically and technologically impractical to use for drinking water or livestock water purposes may be included in subsector guidelines developed for varying geographical regions.
Monitoring	Groundwater Monitoring Directive Draft Groundwater Quality Monitoring and Management for Approved Facilities, Environmental Protection and Enhancement Act (ESRD 2012)	Provides guidance on the establishment of groundwater monitoring programs for Sites falling under the Environmental Protection Enhancement Act. References non-saline groundwater
	Draft - Non-Saline GW in Direct Contact with Bitumen Guide (ERCB 2014)	This Directive pertains only to groundwater quality and only applies to non-saline groundwater. The objective of the Guide is to provide guidance for the assessment and management of non-saline groundwater in direct contact with bitumen for in situ oil sands operations using enhanced bitumen recovery. The Guide is one component of a larger initiative to manage cumulative effects to groundwater quality and quantity in non saline aquifers and connected surface water sources on a regional basis. This Guide is not limited by the base of groundwater protection and focuses on concerns around non saline water in direct contact with bitumen and receptor aquifers. The document does acknowledge that water diverted from an aquifer considered to be in contact with bitumen is typically considered preferred water source during evaluation of the license application. Discussion of Aquifer management units.
	Lower Athabasca Region Groundwater Management Framework (ESRD 2008)	Groundwater Management Unit, prioritize management of key aquifers
	Alberta Tier 2 Soil and Groundwater Remediation Guidelines (AEP 2016)	Definition of Domestic Use Aquifer
	Thermally Mobilized Constituents (AEP 2018a)	This Directive pertains only to groundwater quality and only applies to non-saline groundwater. The objective of this Directive is to ensure that groundwater monitoring plans are developed and implemented such that thermal and chemical effects associated with the heating of aquifers during thermal in situ oil sands recovery are contained within a specified area, ensuring protection of receptors, and that all effects are eventually stabilized and reversed such that baseline groundwater quality conditions are restored. Not all non-saline aquifers and wells pads shall require groundwater monitoring within the development area. Approval applicants conduct a preliminary risk assessment, or screening process, to identify aquifers and wells pads of higher risk which shall require additional monitoring. This assessment is based on the evaluation of sources, pathways and receptors. only high risk aquifer selected for monitoring. High risk aquifers and aquifer management unit defined. Not limited by BGWP
Injection	Directive 008 Surface Casing Depth Requirements (AER 2018a)	Primary purpose of the Directive is to design appropriate depths of surface casing to assist with well control and groundwater protection. Surface casing utilized for effective protection of aquifers classified as useable groundwater. Injection wells must have surface casing set to the base of groundwater protection. Thermal injection and production wells must have surface casing set to depth that meet the requirements of Directive 051 and any additional requirements set by AER. Regulation also defines requirements that must be met when surface casing is not set.
	Directive 009 Casing Cementing Minimum Requirements (AER 1990)	Guide for Cement Requirements for Intermediate and Production Casing (regional and formation specific).
	Directive 051 Injection and Disposal Wells - Well Classifications, Completions, Logging and Testing Requirements (ERCB 1994)	Defines useable groundwater with a total dissolved solids content of 4000 mg/L or less. Requires that useable water bearing zones are isolated from injection zone and from aquifer cross-flow of the injected fluid. All injection wells entering a useable water bearing zone will isolate the injection zone from the useable water zone with a minimum of 25 m below the useable groundwater zone. Wells cannot present any risk to useable groundwater. Containment of injected fluid from useable groundwater must be maintained.
	Directive 059: Well Drilling and Completion Data Filing Requirements (AER 2018b)	Only applies to source wells completed over 150 m bgs. Water flows or artesian flows are considered blowouts, except in cases where a blowout preventer (BOP) is present. Notes that use of nonsaline water for oil and gas purposes must comply with the Water Act which requires authorization from AEP.
	Directive 081 Water Disposal Limits and Reporting requirements for Thermal In Situ Oil Sand Schemes (ERCB 2012)	Produced water described as water that is produced in association with hydrocarbon production from a well that was licensed for the purpose of hydrocarbon production. Brackish water is defined as saline groundwater that has a total dissolved solids exceeding 4,000 mg/L. Fresh water defined as non saline groundwater which has total dissolved solids less than or equal to 4000 mg/L.
	Directive 086, Reservoir Containment Application Requirements for Steam Assisted Gravity Drainage Projects in the Shallow Athabasca Oil Sands Area (AER 2016)	Document describes requirements for injection in a region called the shallow area in the Athabasca Oil Sands Area and information requirements as part of operating in this area. References non saline groundwater.
Sourcing	Water Act Revised Statutes of Alberta (Province of Alberta 2017)	Defines saline and non saline groundwater
	Water (Ministerial) Regulation (Province of Alberta 1998)	Defines that saline groundwater is exempt from licensing requirements, defines requirements for installation of source wells in non saline aquifers
	Water Conservation and Allocation Guidelines (AEP 2016)	Guideline objective is to enhance the conservation and protection of Alberta's water to reduce or eliminate the use of non saline water resources for oilfield injection purposes
	Guide to Groundwater Authorization (Alberta Environment 2011)	Guide applies to non saline groundwater. Diversions of saline groundwater are exempt from requiring a license. Where water is not intended to be used (i.e., construction dewatering) proponents must apply for an approval.
	Directive 008 Surface Casing Depth Requirements (AER 2018a)	Only applies to source wells completed over 150 m bgs. See section on Injection
	Directive 009 Casing Cementing Minimum Requirements (AER 1990)	Only applies to source wells completed over 150 m bgs. See section on Injection
	Code of Practice For Waterworks Systems Using High Quality Groundwater (AENV 2012)	Provides definition for high quality groundwater. Note definition of high quality groundwater is different than that summarized in the *Draft Water Conservation Policy for Upstream Oil and Gas Operations (Drafts) (AEP 2016)*
	Directive for Water Licensing of Hydraulic Fracturing Projects - Area of Use Approach (AEP 2018b)	Specific to hydraulic fracturing projects. Discussion of Alternative water sources. Less-restrictive point of use determination at licensing. Acknowledges that guidelines can be tailored based on sub-sector and geographic area.
	Directive 059: Well Drilling and Completion Data Filing Requirements (AER 2018b)	Only applies to source wells completed over 150 m bgs. See section on Injection

References:

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Alberta Energy Regulator (AER). 2018b. Directive 059: Well Drilling and Completion Data Filing Requirements. March 12, 2018.
Energy Resources Conservation Board (ERCB). 2014. Draft Guidance for the Assessment and Management of Non-Saline Groundwater in Direct Contact with Bitumen for In Situ Operations. February 2014.
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Government of Alberta (GoA). 2003. Water For Life - Alberta's Strategy for Sustainability. ISBN No. 0-7785-3058-2 Pub. No. I/955. November 2003.
Province of Alberta. 2017. Water Act. Revised Statutes of Alberta 2000 Chapter W-3. Current as of December 15, 2017. Alberta's Queen's Printer, Edmonton, Alberta.
Province of Alberta. 2008. Land-use Framework. ISBN No. 978-7785-7713-3. Pub No. I/321. December 2008.
Province of Alberta. 1998. Water Act, Water (Ministerial) Regulation. Alberta Regulation 205/1998. With amendments up to and including Alberta Regulation 240/2017. Alberta Queen's Printer, Edmonton, Alberta.

TABLE 2 Groundwater Definitions

Term	Definition	Reference
Saline Groundwater	Refers to water that has total dissolved solids exceeding 4,000 milligrams per litre	Province of Alberta. 1998. Water Act, Water (Ministerial) Regulation. Alberta Regulation 205/1998. With amendments up to and including Alberta Regulation 240/2017. Alberta Queen's Printer, Edmonton, Alberta.
Fresh Water (Non-Saline)	Refers to either nonsaline groundwater, which is groundwater that has a total dissolved solids less than or equal to 4,000 miligrams per litre, or surface water, which is as defined in Part 1(1)(bb) of the Alberta *Water (Ministerial) Regulation* as "all water on the ground surface, whether in liquid or solid state." A freshwater source may refer to: - a well licensed by the ERCB drilled to a depth of greater than 150 m - a shallow well with a depth of less than 150 m - a surface water source, such as a diversion point at a lake or a river (regardless of TDS) - surface runoff collected Regardless of the source, all freshwater use requires a diversion licence from ESRD in accordance with the *Water Act*	Energy Resources Conservation Board (ERCB). 2012. Directive 081: Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes. November 2012.
High Quality Non-Saline	Non-saline groundwater and surface water supplies that support instream and aquatic ecosystem needs and/or are useable with standard treatment technologies for drinking Refers to groundwater that: (i) does not require treatment to comply with the applicable physical, chemical, and radiological MAC, except for flouride, specified in the GCDWQ, for the parameters listed in the Standards and Guidelines Document (ii) contains a concentration of naturally occuring fluoride of less than or equal to 2.4 mg/L (iii) is not under the direct influence of surface water	Alberta Environment (AENV). 2012. Code of Practice for Waterworks Systems using High Quality Groundwater. Environmental Protection and Enhancement Act. RSA 2000. cE-12. Effective June 1, 2012.
Alternative Non-Saline	A source that can replace surface water or non-saline groundwater of high quality. Municipal and industrial wastewater and water that has been contaminated with hydrocarbons in the bitumen extraction process are alternative sources. Alternative water sources include: - Tailings water and other industrial process-affected water (PAW) - Unprocessed, impaired quality non-saline groundwater (i) Non-saline water in contact with petroleum (e.g., top/bottom water) (ii) Non-saline water with elevated persistent contaminants (e.g., boron, arsenic, fluoride, methane, H2S) - Transferred produced water that currently could be classified as fresh water, saline water, or produced water depending on interpretation and salinity	Alberta Environment and Parks (AEP). 2016. Water Conservation Policy for Upstream Oil and Gas Operations (Draft). October 2016. Canadian Association of Petroleum Producers (CAPP). 2012 . Re: Draft Directive: Water Disposal Limits and Measurement and Reporting Requirements for Thermal In Situ Oil Sands Schemes. Letter submitted to T.Keelan, K. Fiakpui, From E. Varga. https://www.aer.ca/documents/directives/Directive081_StakeholderFeedbackSubmissions.pdf
Produced Water	Water that is produced in associated with hydrocarbon production from a well that was licensed for the purpose of hydrocarbon production.	Energy Resources Conservation Board (ERCB). 2012. Directive 081: Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes. November 2012.
Base Groundwater Protection (BGWP)	The BGWP is developed on a regional geologic basis and is the best estimate of the depth at which saline groundwater is likely to occur using the data available at the time. The EUB recognizes that local variations may exist that are not captured by a regionally based assement. Term usable groundwater removed. In any case where BGWP is calcuated to be deeper than 600 mbgs the BGWP can be defaulted to 600 mbgs.	Alberta Energy and Utilities Board (EUB). 2007. ST55-2007: Alberta's Base of Groundwater Protection (BGWP) Information. April 19, 2007.
Usable Groundwaters	Groundwater above Base of Groundwater Protection	Alberta Energy Regulator (AER). 2018. Directive 008: Surface Casing Requirements. January 31, 2018. Energy Resources Conservation Board (ERCB). 1994. Directive 051: Injection and Disposal Wells - Well Classifications, Completions, Logging, and Testing Requirements. March 1994.
Domestic Use Aquifer	The definition of a DUA is dependant on the amount of water an aquifer can produce, rather than the quality of the water in the aquifer, recognizing that technological treatment methods exist that can reduce or remove natural background substances. An aquifer does not have to be currently used for domestic purposes in order to be classified as a DUA, as the intent is to define and protect these aquifers for current and future use. ESRD may consider any body of groundwater above the BGWP that is capable of a sufficient yield of water to be a DUA. A DUA is defined as a geologic unit that is above the BGWP having one or more of the following properties (1) a bulk hydraulic conductivity of 1 x 10^{-6} m/s or greater and sufficient thickness to support a sustained yield of 0.76 L/min or greater; or (2) is currently being used for domestic purposes or (3) any aquifer determined by ESRD to be a DUA.	Alberta Environment and Parks (AEP). 2016. Alberta Tier 2 Soil and Groundwater Remediation Guidelines. Land and Forestry Policy Branch. Policy Division. 151 pp.
Aquifer Management Unit	AMUS are defined at those non-saline aquifers within the management area where effects associated with the heating of the subsurface are expected to be observed and have been selected for additional monitoring. Approval applicants and holders are not expected to monitor every non-saline aquifer but rather those that have been deemed to have higher risk. Risk based on criteria such as but not limited to (1) water quality, (2) location of receptors, and (3) groundwater usage. A nonsaline aquifer could be identified as an AMU if it is (1) potentially regional in scale. (2) is being used or has the potential to be used for domestic supply or agricultural purposes(i.e., high yield/high quality), (3) traditional land use features associated with groundwater, (4) is know or has the potential to discharge to a wetland or wetland complex, (5) is known or has the potenital to discharge to a surface water body, or (6) is of high permeability or is influenced by aquifers of high permeability.	Alberta Environment and Parks (AEP). 2018. Assessment of Thermally-Mobilized Constituents In Groundwater for Thermal In Situ Operations. Water Quality, 2018, No. 1. June 1, 2018.
Groundwater Management Unit	Used to prioritize the management of key regional aquifers. the classificication of aquifers helps focus groundwater management priorities for the region. A number of aquifers have been identified as having A higher priority with respect to protection.	Alberta Environment and Sustainable Resource Development (ESRD). 2008. Lower Athabasca Region Groundwater Management Framework. ISBN 978-I-4601-0533-7.
Brine Equivalent	Aqueous salt solutions that are equivalent to produced water in the opinion of AEP and the ERCB	Energy Resources Conservation Board (ERCB). 1994. Directive 051: Injection and Disposal Wells - Well Classifications, Completions, Logging, and Testing Requirements. March 1994.

APPENDIX C
Summary of Industry Meeting November 19, 2018
(Task 5)

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

MEMORANDUM

TO: Mike De Luca, PTAC (Industry Technical Champion)

FROM: William Wilmot, Hugh Abercrombie and Ron Coutts, Matrix Solutions Inc.

SUBJECT: Summary of Industry Meeting November 19, 2018 (WIPC 1801)

DATE: November 20, 2018

1 BACKGROUND

Task 5 of the WIPC 1801 project entitled *Develop Definitions for Alternative Water Sources to High Quality Non-saline Groundwater* required Matrix Solutions Inc. to meet with PTAC industry representatives to solicit thoughts and perspectives regarding:

i. expanding the draft policy definition of "alternatives to high quality non-saline water" and;

ii. criteria to define a workable definition of "non-saline groundwater that is economically and technically impractical to use for drinking water supplies or livestock purposes."

Guided by industry experience and perspective, Matrix will provide recommendations to meet the project objectives.

2 INDUSTRY MEETING

The meeting with PTAC industry representatives was held on November 19, 2018, at the Matrix Calgary office. Industry Technical Champion Mike De Luca provided the meeting invitation list to Matrix. The following people were invited:

- Brent Moore (CNRL) - present
- Deanna Cottrell (Shell) - present
- JoAnne Volk (Repsol) - present
- Luke Donnelly (Repsol) - present
- Mike De Luca (Husky) - present
- Paul Martin (ConocoPhillips) - present
- Scott Hillier (Cenovus) - present
- Tara Payment (CAPP) - present
- Scott Rayner (MEG) – present (*in lieu of Agata Nowak*)
- Anita Selinger (Suncor) – declined
- James Armstrong (EnCana) – declined
- Janet McNally (NuVista) – no response
- Bill Wilmot, Hugh Abercrombie and Ron Coutts (Matrix) - present

3 ALTERNATIVES TO HIGH QUALITY NON-SALINE WATER

Five alternatives to high quality non-saline water are presented in the draft Alberta Environment and Parks (AEP) document entitled *Water Conservation Policy for Upstream Oil and Gas Operations* (AEP 2016) as follows:

a) Recycled or reconditioned industrial and municipal wastewater, taking return flows into perspective;

b) oil sands mining tailings pond water;

c) non-saline water in direct contact with bitumen deposits;

d) naturally occurring non-saline water containing petroleum hydrocarbon compounds (excluding methane) within formations that contain both water and hydrocarbon resources;

e) non-saline groundwater that is demonstrated to be economically and technologically impractical to use for drinking water or livestock watering purposes, taking into consideration the local hydrogeological setting, as it pertains to hydraulic connectivity in support of instream and aquatic ecosystem needs and availability of other water supplies for existing or potential water users in the area.

The first objective of the meeting was to review the list above, and consider additional alternatives and discuss refining the definitions for alternatives a) through d). The second objective was to review alternative e) above and compile industry perspective on what is "economically and technologically impractical."

4 PROCEDURES

4.1 Project Scope

It was assumed all PTAC industry representatives at the meeting were familiar with the details and objectives of the meeting; however, to ensure all meeting participants shared common background information, Bill Wilmot (Matrix) briefed the participants about the project background, objectives, tasks, and status.

4.2 Industry Perspective

Most of the meeting was an open discussion regarding alternative water sources. All attendees were given an opportunity to contribute to the conversation and express their views. Prior to the meeting, those who would not be attending were instructed to provide their thoughts to the Industry Technical Champion (Mike De Luca) at their discretion. At the close of the meeting, attendees were encouraged to contact Bill Wilmot (Matrix) with any new thoughts subsequent to the meeting.

4.2.1 Alberta Energy Regulator/Alberta Environment and Parks Meeting

During the meeting, key findings from the AEP/AER meeting on October 4 (Task 2) were shared with the attendees. Those key findings were summarized under a separate memorandum.

4.2.2 Jurisdictional Review

During the meeting, key findings from the Matrix jurisdictional review (Task 3) were shared with the attendees. Those key findings were summarized under a separate memorandum.

5 KEY FINDINGS

Based on the meeting, key findings were identified as presented in the next sections.

5.1 Definitions of Alternatives

- The definition of naturally occurring non-saline water containing petroleum hydrocarbon compounds (excluding methane) within formations that contain both water and hydrocarbon resources should consider free gas as well as dissolved constituents.

- Impacted non-saline groundwater could be considered an alternative to high quality non-saline water (for example, contaminated groundwater including but not limited to landfill leachate and acid mine drainage).

- Surface runoff from regulated upstream petroleum sites could be considered an alternative to high quality non-saline water if the water does not meet release to environment criteria provided in Directive 055 (ERCB 2001).

5.2 Economically and Technologically Impractical

- During the meeting with industry representatives, it was discussed that AER met with CAPP (just a few days earlier) on November 16, 2018, to inform and solicit feedback about an update to Directive 081 (*Water Disposal Limits and Reporting Requirements for Thermal In Situ Oil Sands Schemes*), planned for release in early-2019. It was also relayed that during the CAPP meeting on November 16, there was discussion about AER's preliminary thoughts on economically and technologically impractical non-saline groundwater alternatives in the context of Directive 081. PTAC industry representatives that were present at the CAPP meeting mentioned to Matrix during the industry meeting that AER discussed a possible definition that considered the concepts of water-short areas; Neogene and Quaternary aquifers; and a depth criterion of 150 m below grounds surface (bgs).

- Attendees of the CAPP meeting who also attended the Matrix industry meeting provided a generally favourable opinion of the AER approach.

- Those in attendance at the Matrix industry meeting (but not CAPP meeting) also advocated some possible suggestions intended to improve the AER approach. These suggestions included:

    - Bedrock aquifers naturally containing free hydrocarbons (excluding methane) at depths of less than 150 m bgs could also be considered an alternative to high quality non-saline groundwater.

It is unlikely these types of aquifers would be utilized for domestic or livestock purposes because of the cost of treating hydrocarbons in water, desire of stakeholders to find other more suitable sources for domestic use, and the geographic location where these aquifers occur less than 150 m bgs are often removed from non-industry groundwater use.

- In cases with unique circumstances, a risk-based approach could be considered at the discretion of the Director. The risk-based approach should incorporate groundwater utility/competition and aquifer connectedness to surface.

CLOSURE

This document summarizes the key findings from the meeting on November 19, 2018, with PTAC industry representatives. The key findings from this meeting (Task 5) will be compared to the key findings of the AEP/AER meeting (Task 2), and the jurisdictional review (Task 3), to identify similarities and consistencies. Matrix will then prepare a concise summary report containing recommendations for WIPC to review (Task 7). A report addressing the review edits and comments will then be presented to PTAC (Task 8). AEP/AER has declined Task 6, which involved re-engaging AEP and AER to review and revise recommendations if necessary. AER/AEP representatives clearly stated their expectation that recommendations must come directly from industry via this project without AEP/AER involvement in refining the recommendations.

REFERENCES

Alberta Environment and Parks (AEP). 2016. *Water Conservation Policy for Upstream Oil and Gas Operations*. October 2016.

Energy Resources Conservation Board (ERCB). 2001. *Directive 055: Storage Requirements for the Upstream Petroleum Industry*. Calgary, Alberta. December 2001. http://www.aer.ca/documents/directives/Directive055.pdf