APPENDIX B

Water Intake and Discharge Facilities

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

ALTON NATURAL GAS STORAGE LP

ALTON NATURAL GAS STORAGE INTAKE AND DISCHARGE FACILITIES PRELIMINARY DESIGN STUDY SHUBENACADIE RIVER, N.S.

FEBRUARY, 2007
Matrix File: 6639

ALTON NATURAL GAS STORAGE LP
WATER INTAKE AND DISCHARGE FACILITIES
PRELIMINARY DESIGN STUDY
SHUBENACADIE RIVER

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reviewed by ______________________________

Full Name of Reviewer, designation(s)
Position/Title

February 2007
Calgary, Alberta

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

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1.0 INTRODUCTION

The Alton Natural Gas Storage project will involve withdrawing river water from the Shubenacadie River to dissolve salt formations in order to create gas storage caverns and the brine, produced in creating the salt caverns, will be discharged back into the Shubenacadie River.

This report addresses the:

- River water intake facilities at the Shubenacadie River and,
- The discharge facilities of the brine solution back into the river.

It focuses on the design objectives and criteria, the available date base, an evaluation of discharge options and the mode of operation and conceptual design of the selected option.

The water discharge modelling, done to evaluate the various options, was undertaken by Martec Inc. of Halifax. River and ground surveys were also by Martec. Environmental input was provided by Jacques Whitford (Virginia Soehl). The mode of operation of the discharge facilities was discussed and developed with Landis Energy Corporation (David Birkett and John Hilland) and Soltech Projects Inc. (Bob Ramsey). Matrix Solutions Inc. prepared this report from the above, numerous meetings and their river engineering and hydraulic assessments which were supported by two field evaluations by Wim M. Veldman, M.Sc., FEIC, P.Eng.

2.0 OBJECTIVES AND CRITERIA

The selection of the optimum intake and discharge methodology and its conceptual design was predicated on the following objectives and criteria:

- The salinity of the brine discharge into the river shall mimic or mirror, to the fullest extent practical, the natural salinity in the river and shall not exceed, in normal operations, 25 ppt, the typical maximum natural salinity in the river.

- The maximum daily water withdrawal from the river, required to create the salt caverns, shall be 11,750 m^3/day of which 1750 m^3/day will return directly to the river as discharge from the hydrocyclones, which remove most suspended matter. At the beginning of the formation of a cavern, the withdrawal rate is less.

- The average daily brine discharge or return flow to the river from the caverns is about 90% of the withdrawal, as some water will remain in the caverns to displace dissolved salt. The maximum instantaneous flow into the mixing pond may be 50% greater since in certain periods of the tidal cycle, there will be zero brine discharge to meet environmental and water quality criteria. A brine holding pond will retain brine during periods of zero discharge, allowing continuous brining of caverns.

- The maximum salinity of the return flow from the caverns will be 260 ppt (salt saturated). In the first year of the development of any cavern, the salinity from the cavern will be less than saturated.

- The operation of the discharge facilities will be computerized in order to synchronize discharges in accordance with the tidal cycle and the prescribed water quality objectives.

- Intake and outlet facilities will be screened, in accordance with relevant provincial and federal guidelines for striped bass, Atlantic salmon, and Atlantic sturgeon. Debris racks will be used to protect gated structures and the fish screens from ice and debris (logs).

- The discharge facilities will be designed to enable their isolation from the river, if necessary, for any maintenance activities.

3.0 GIVENS AND DATA BASE

In assessing the various intake and discharge methodologies and impacts, the following data, and information was utilized.

- The river's reach selected for the intake and discharge facilities was in accordance with the location of the proposed caverns and routing considerations for the pipelines to and from the caverns.

- A dike on the right or east bank of the river was constructed more than 100 years ago (according to local residents) to prevent flooding of the adjacent land. The riprap on the dike was added in about the seventies. From knowledge of local residents and provincial authorities, little maintenance of the dike has been required in the past. Comparative aerial photographs from 1964 to 2004 (Figures 1 and 2) indicate that no significant historic river changes have occurred in the proposed facility area. Future river patterns are also not expected to alter significantly. Site photos are provided in Figures 3 - 5. The proposed Alton facilities at the river shall ensure and maintain the integrity of the existing right bank dike.

- Non-tidal Shubenacadie River flow magnitudes (Figure 6) are as per the Water Survey of Canada gauge at Enfield (WSC Gauge No.01DG006) and extrapolated in conjunction with Water Survey of Canada flows on the Stewiacke River, in a linear manner on a drainage area basis, to account for the incremental drainage area between the measurement location and the proposed facilities.

- Site specific flow, water level, salinity and temperature data collected by Martec Inc. in August to December 2006 (Figure 6). The salinity versus tidal patterns indicate that:
    - Salinity levels are lowest obviously during the non-tidal, river flow conditions and at the beginning of the incoming tide which displaces the fresh river flow in an upstream direction.

    - The highest salinity levels correspond to the peak of the flood flow, the time of the maximum tide and water levels.

- The magnitude of the incoming river flow on the Shubenacadie and Stewiacke Rivers will affect the salinity magnitude especially during the transition period from ebb tide to river flow.

4.0 EVALUATION OF DISCHARGE OPTIONS

Three options were considered to discharge the 260 ppt brine (maximum concentration) from the leaching facility into the Shubenacadie River. These were:

- A multi-port diffuser line into the river (Option 1, Figure 7).
- A single port outlet into the river which combines, prior to discharging into the river, ten parts of river water with one part of brine from the leaching facility (Option 2, Figure 8).
- A gravity fed pond parallel to and adjacent to the river which pre-mixes the brine with river water prior to releasing it into the mainstream of the river (Option 3, Figure 9).

The **multi-port diffuser** would project into the flow depth influenced by ice floes, a significant design concern. Regulatory approval from the Federal Navigable Waters branch for projections above the streambed in the Shubenacadie River could be difficult. Excavation and placement of the line and its projections in the high velocity tides and shifting bed levels will pose a significant construction and thus cost challenge. From an environmental viewpoint, the salinity concentration at the "end of the pipe" would equal that of the brine from the leaching facility. This Option **was not pursued further** for the design, cost and regulatory challenges indicated.

A **single port outlet**, either a pipe or a simple open channel outlet into the Shubenacadie River would not pose the design and navigable waters challenges of the multi-port diffuser. Pumping cost for the high volume mixing flow required, about 10 times the return flow from the leaching facility, would result in high annual operational costs. Also, it would be technically difficult to pump the required volume of water within a limited time during each tidal cycle. Consequently this Option **was not pursued further**.

The third option considered was a **gravity fed mixing pond** parallel to the river, which would serve as a large pre-mixing zone prior to release into the river. Mixing, from a salinity viewpoint would be maximized by capturing the non-tidal river flow to the fullest extent possible and by timing the discharge of the brine into the pond to coincide with the higher salinity flood tide respectively. This option would not require pumping. A large land area would be required adjacent to accommodate the proposed pre-mixing pond. The excavated material would be placed as secondary dikes to provide additional protection to the adjacent low lying lands. Fish screens will be necessary at the inlet and outlet to exclude fish from the pre-mixing pond. From an **operational, construction and environmental viewpoint, this is the recommended option.**

5.0 OPERATIONAL AND DESIGN GUIDELINES FOR THE PRE-MIXING POND

The conceptual layout and design of the inlet and pre-mixing pond/outlet are illustrated on Figures 9 and 10 respectively. The operational criteria are listed below followed by the required design features to meet these criteria.

5.1 Operational Criteria and Guidelines

The operational criteria and guidelines are:

During the lower part of the ebb flow and the beginning of the flood flow, when the salinity is at its lowest* (Figure 11), the upstream and downstream** outlets of the pre-mixing pond will be fully open in order to first drain out the tide-induced storage from the previous cycle and to maximize the storage of non-tidal river water which occurs at the end of the ebb flow cycle and the beginning of the tidal bore and flood flow, the latter a period when the incoming tide conveys the non-tidal river water upstream. The total duration of this period would be about 4 hours. There would be no discharge of brine to the pre-mixing pond and thus to the river during this period.

*The actual salinity is variable depending on the magnitude of river flow and the characteristics of the tide. What is important from an operational view point is that the brine from the leaching facility will have to be stored for fours hours, the end of the ebb flow period and the beginning of the flood flow, the period of lowest salinity.
** As referenced to normal river, non-tidal flow.

- With the incoming tidal flow, brine discharge into the pond will commence while the upstream gates will be closed (Period 2). This gate closing is required to prevent short-circuiting the brine discharge into the water intake for the brining facility - the brine discharge into the pond will be located at its upstream end to maximize the mixing prior to release to the river.

- At the peak water level of the tide, the upstream gates will be opened to ensure the pre-mixing pond drains in parallel with the drop in the river's water level. Furthermore, with the upstream and downstream ends of the pond both open, flow-through the pond will maximize pre-mixing in the pond.

- The natural salinity concentrations in the river vary according to the tidal conditions and the river's runoff flow. The computerized operation of the upstream inlet to the pond - the downstream outlet will always be open - will be set to the timing of the tidal cycle. In this manner, brine releases into the pre-mixing pond and thus into the river will always be terminated during the 4 hour period when salinity concentrations in the river are at their lowest (Figure 12). Releases into the river in the subsequent 8 hours will occur when natural saline concentrations in the river are at their highest (Figure 12). Thus the releases into the pre-mixing pond and the resultant salinity of the flow into the river will be timed to mimic the natural salinity variations in the river.

5.2 Design Features

To meet the design objectives of Section 1.0 and the operational criteria of Section 4.1 we will require the following design features:

- Adequately sized intake and outlet facilities to ensure full circulation into and out of the pre-mixing pond in every tidal cycle. The twice daily rise and fall in water levels will generate, like that experienced in the river, strong currents in the pond which will enhance the mixing of the brine with river water in the pond before it is released into the river.

- Upstream intake gates, protected with screens and debris racks, will:
  - Be sized to handle the necessary flow;
  - Prevent the movement of fish into the pond;
- Downstream outlet fish screens and debris racks.
- Armouring of the pond slopes to prevent erosion in high velocity areas in the inlet and outlet channels and in the curved channel sections leading into the pre-mixing pond.
- In the event the pre-mixing pond needs to be isolated from the river for maintenance reasons - silt removal may be required at some point - the upstream gates will be closed and a temporary cofferdam (gravel or sand bags or an "aquadam") installed across the downstream opening.
- The bottom of the pond, at about the maximum depth of the river, will be excavated into the native material. A liner is not considered to be necessary as the pond's bottom will be at or nearly the same elevation as that of the river bottom. Without a liner, sediment removal, if necessary, will be facilitated.
- The excavated material will be placed as dikes around the pond. A 10m setback from the top of the excavation to the inside edge of the dikes (Figure 9) will be utilized for geotechnical stability reasons and to facilitate maintenance of the pond's slopes and armouring if necessary. The dikes will be constructed at stable slopes and sufficiently flat enough (3H:IV to 5H:IV) to facilitate maintaining the grass surface of the dikes.

The conceptual design of the proposed works is illustrated on Figures 9 and 10. In the detailed design stage, the number, elevation, and size of gates will be refined. Water quality modelling of the pre-mixing pond will refine its total size and dimensions. Generally speaking, a long linear pond is foreseen to maximize the length of pre-mixing prior to discharge into the River.

The pre-mixing pond discharge option is believed to be the optimum environmental solution to discharging the brine into the river in accordance with regulatory requirements. The unique and significant tidal fluctuations on the Shubenacadie River are attributes in achieving the required pre-mixing as the tide will generate significant water level changes and strong currents into and out of the pond.

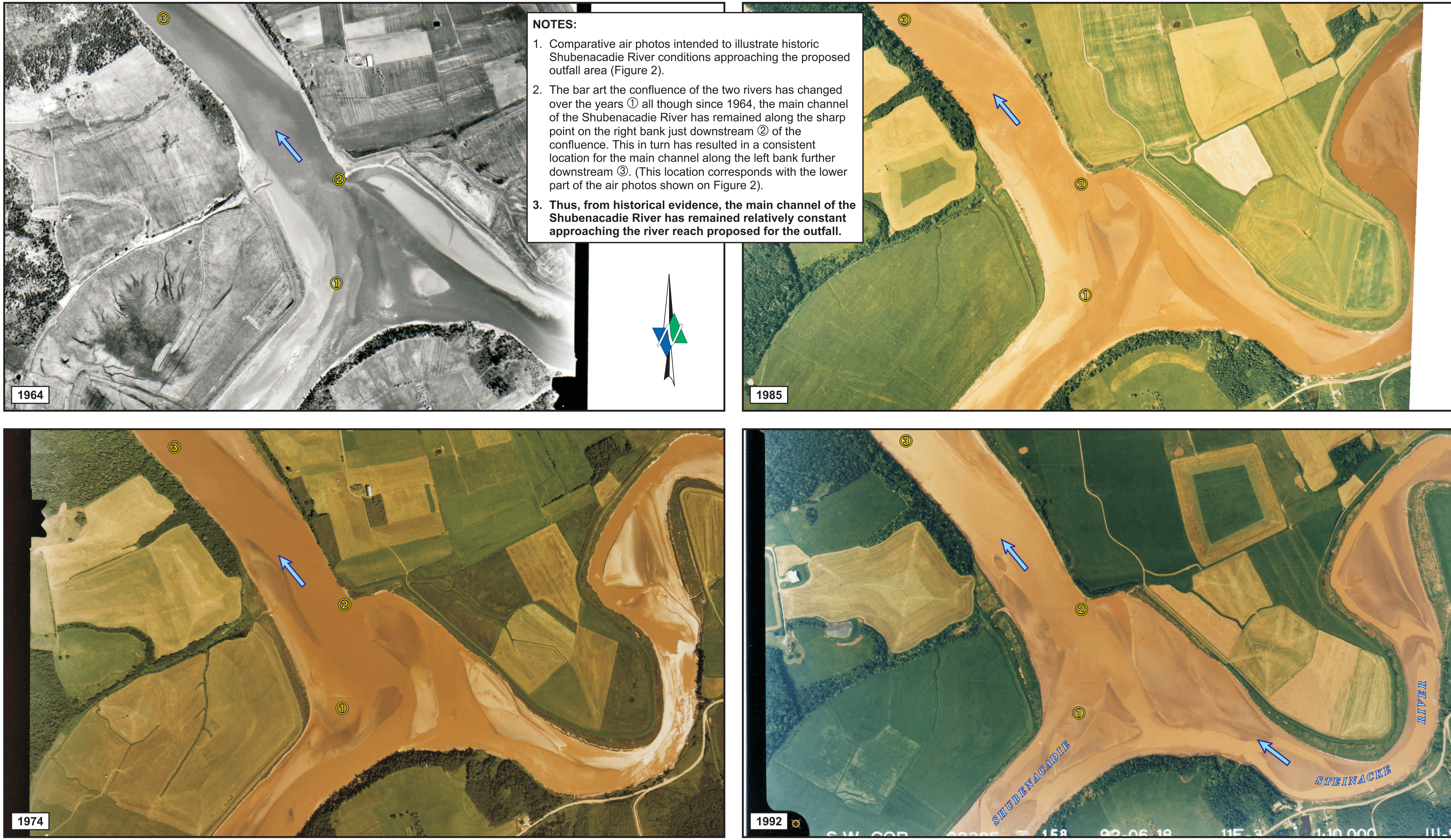
6.0 WATER INTAKE FOR THE SALT CAVERN

The water intake will be incorporated into the intake for the pre-mixing pond as illustrated on Figure 10. The vertical sheet pile wall will induce local scour - the proposed intake structure will be located on the outside of the bend in a stable reach of the river (see Figures 1 and 2) - a necessity to ensure adequate water supply and operation during low river flows.

The gate will normally always be open. For maintenance reasons, the gate can be closed to enable dewatering of the wetwell at the intake.

NOTES:

1. Comparative air photos intended to illustrate historic Shubenacadie River conditions approaching the proposed outfall area (Figure 2).
2. The bar art the confluence of the two rivers has changed over the years ① all though since 1964, the main channel of the Shubenacadie River has remained along the sharp point on the right bank just downstream ② of the confluence. This in turn has resulted in a consistent location for the main channel along the left bank further downstream ③. (This location corresponds with the lower part of the air photos shown on Figure 2).
3. **Thus, from historical evidence, the main channel of the Shubenacadie River has remained relatively constant approaching the river reach proposed for the outfall.**



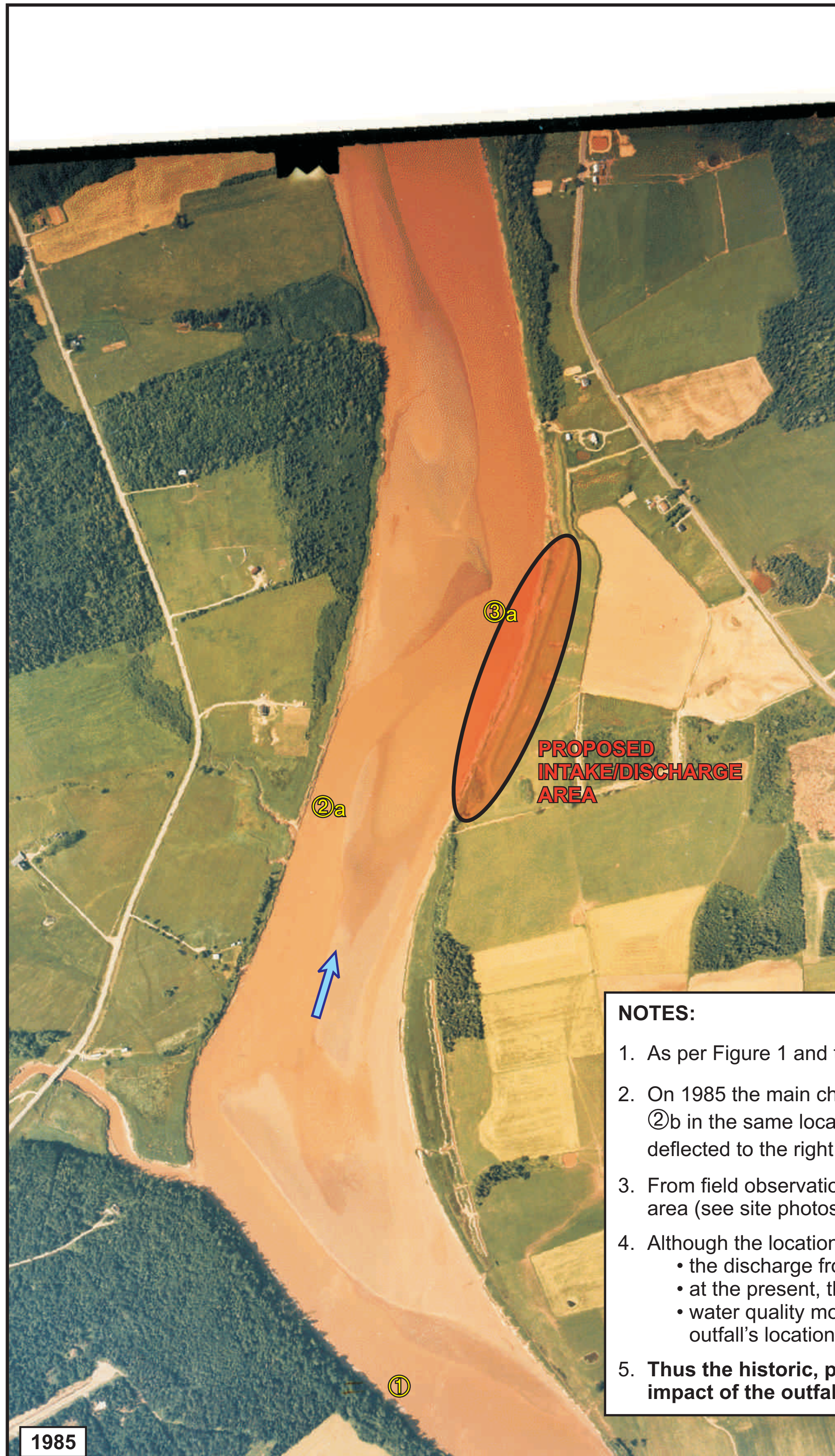
Scale 1:10 000 0 100 200 400 Metres

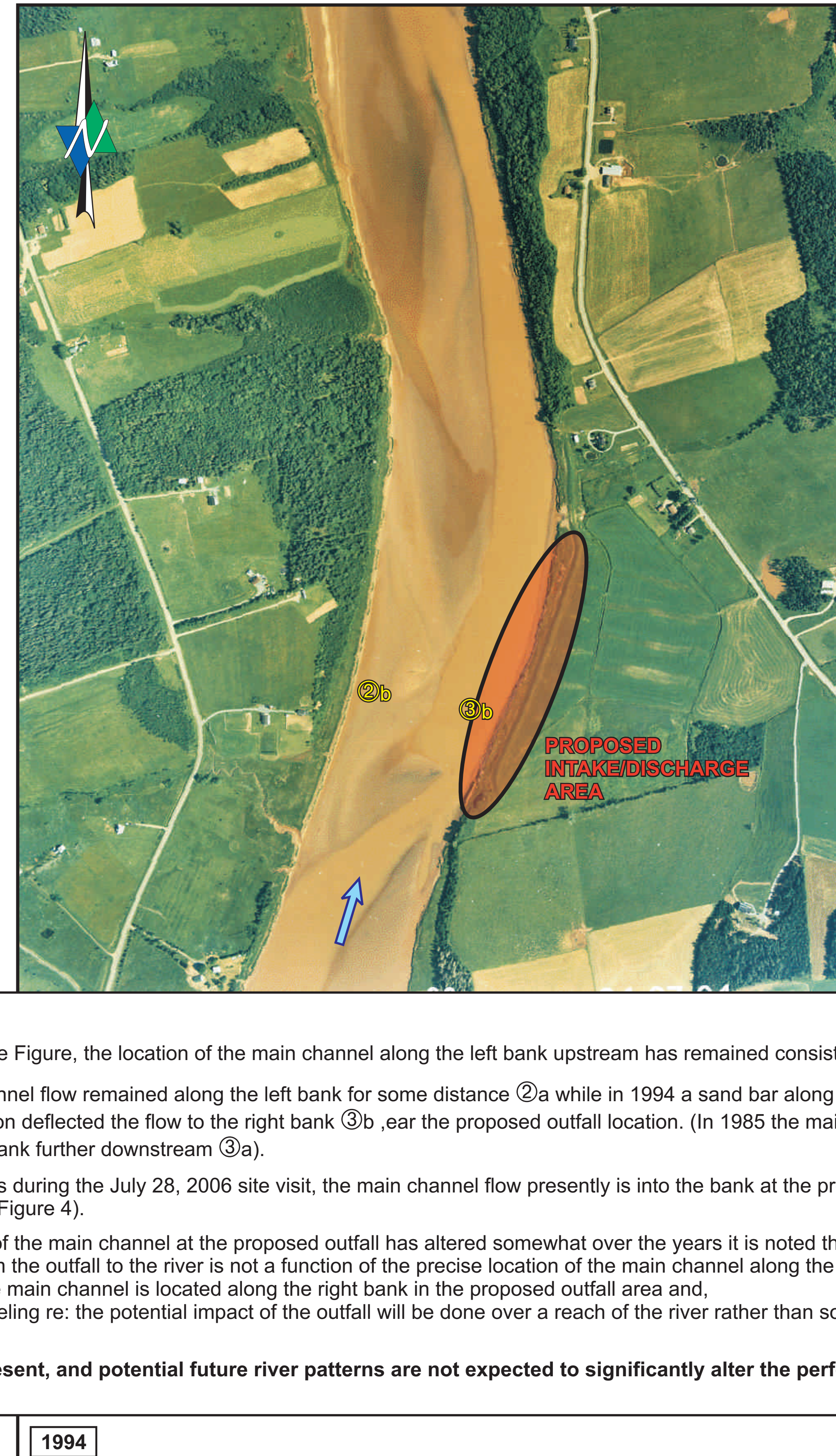
Matrix Solutions Inc. ENVIRONMENTAL CONSULTANTS

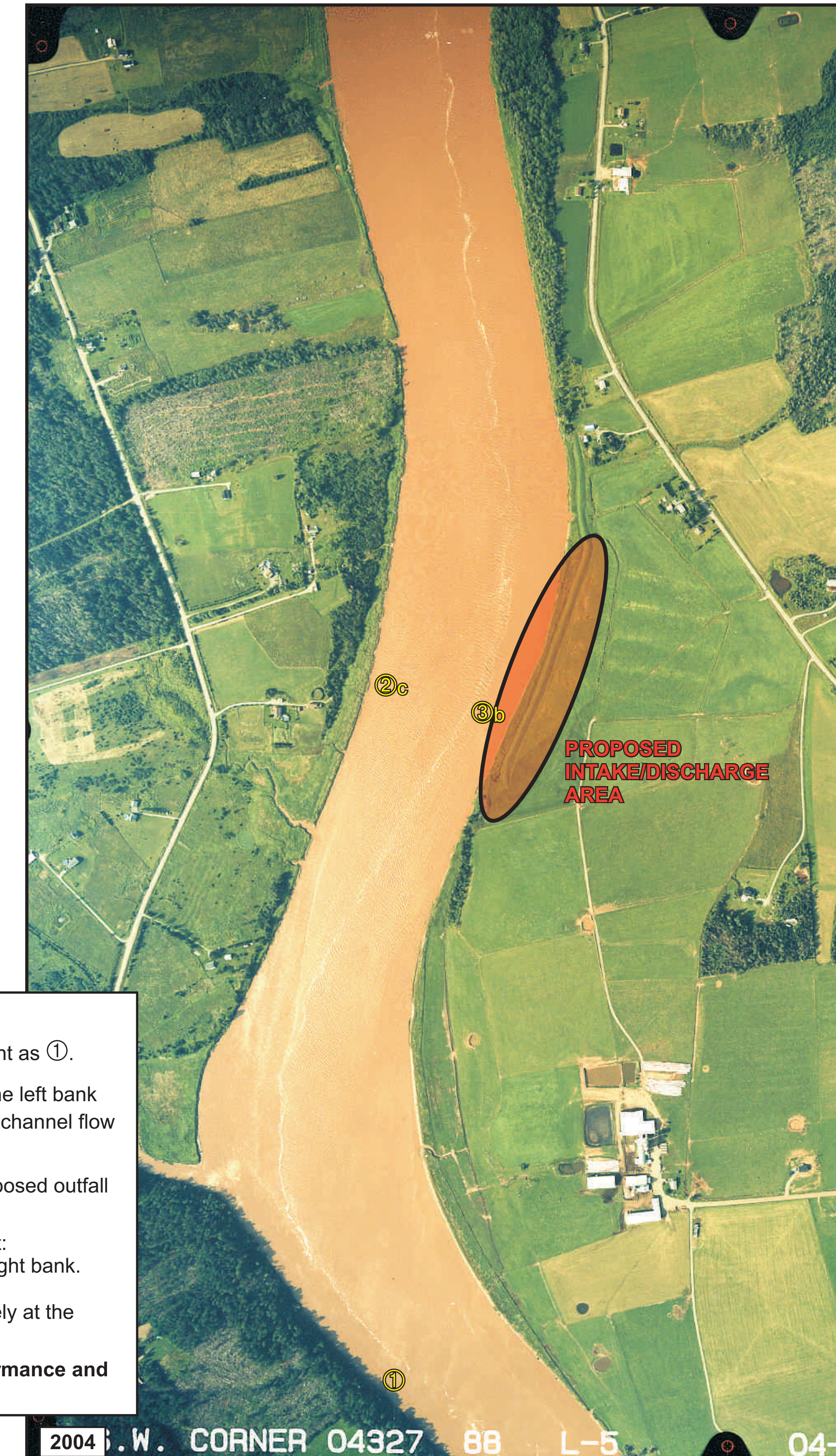
LANDIS ENERGY CORPORATION

DRAFT

DATE: OCTOBER 11, 2006	PROJECT: ALTON NATURAL GAS STORAGE
JOB No.: 6639-522	**1964 - 1992 COMPARATIVE AIR PHOTOS OF SHUBENACADIE RIVER APPROACHING THE OUTFALL AREA**
COREL FILE: 6639-Figures-06	
DESIGN: WV / DRAWN: JW / CHECK: WV	FIGURE: 1







NOTES:

1. As per Figure 1 and the Figure, the location of the main channel along the left bank upstream has remained consistent as ①.
2. On 1985 the main channel flow remained along the left bank for some distance ②a while in 1994 a sand bar along the left bank ②b in the same location deflected the flow to the right bank ③b ,ear the proposed outfall location. (In 1985 the main channel flow deflected to the right bank further downstream ③a).
3. From field observations during the July 28, 2006 site visit, the main channel flow presently is into the bank at the proposed outfall area (see site photos, Figure 4).
4. Although the location of the main channel at the proposed outfall has altered somewhat over the years it is noted that:
   - the discharge from the outfall to the river is not a function of the precise location of the main channel along the right bank.
   - at the present, the main channel is located along the right bank in the proposed outfall area and,
   - water quality modeling re: the potential impact of the outfall will be done over a reach of the river rather than solely at the outfall's location.
5. **Thus the historic, present, and potential future river patterns are not expected to significantly alter the performance and impact of the outfall.**

Scale
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1985 - 2004 COMPARATIVE AIR PHOTOS OF SHUBENACADIE RIVER IN THE OUTFALL AREA

FIGURE:
2