



Elbow Lake

LITERATURE REVIEW

WATER QUALITY IN THE UPPER ELBOW RIVER WATERSHED

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Elbow River Watershed Partnership

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INTRODUCTION

A variety of reports have been issued relating to the general health of the Elbow River over the last three decades and all of these reports have provided valuable information that relate to water quality. This report was commissioned by the Elbow River Watershed Partnership (ERWP), to provide an overall picture of general changes that affect water quality over time, and to compare with more current studies. In this way, relevant historical information can be used, maintained, updated and built upon without being lost to dusty bookshelves and forgotten. In addition, the lessons learned from the water quality studies will be reintroduced and examined for future studies under current conditions.

Many studies have been completed on the Upper Elbow River Watershed for the Elbow River Watershed Partnership (ERWP). Studies are primarily from The City of Calgary which also conducts regular monthly monitoring and reporting every two years. Other reports include those completed by Cows and Fish in 2007 (Cows & Fish 2008) and at selected tributaries in 2012 (Cows & Fish 2013). Water quality studies have also been completed by the University of Calgary and the most comprehensive study was completed as a joint study by Alberta Environment and The City of Calgary in 2004 (Sosiak & Dixon 2004).

The floods that occurred in 2013 changed the landscape of much of the Elbow River and studies completed prior to the flood may not relate as much to the post flood conditions, especially in terms of riparian habitat. Although riparian studies do not provide direct water quality results, riparian vegetation has an overall effect on water quality especially for the tributaries. Even three years after the flood in 2013, riparian vegetation has not re-established itself in much of the flood affected areas.

In order to keep the information current by comparing issues related to water quality, it is important to note the various factors that can affect water quality both naturally and anthropogenically. This report looks at the overall background watershed and river characteristics, river tributaries and water quality in the mainstem Upper Elbow River. It also includes some of the history and current situation in terms of wastewater discharge (both direct and indirect) into the Elbow River.

A BACKGROUND DESCRIPTION OF WATER QUALITY IN THE UPPER ELBOW RIVER

The river originates from its source at Elbow Lake in the foothills of the Rocky Mountains from where it runs mostly through Kananaskis country for approximately 62 kilometers to Bragg Creek (Figure 1). The river goes on for approximately another 41 km to Glenmore Reservoir in Calgary and finally reaches the Bow River after another approximately 10 km. It is worth noting that all of the water quality data collected on the Elbow River does not include water quality upstream of the Little Elbow River. The region upstream of the confluence with the Little Elbow River is not developed, although the steep sloping catchment areas (erosional effects), and the potential influence from climate change, may have an influence on water quality.

Flow rates in the Elbow River as measured at Bragg Creek range from approximately 3 to 5 m³/s in the early spring (April) and fall, to approximately 20 to 30 m³/s during the freshet in late May to June. Similar flow rates have been recorded at Sarcee Bridge but with slightly higher peak flows up to 40 m³/s. The river is fed by snowmelt, wetlands and alluvial aquifers and is home to the threatened westslope cutthroat trout (AESRD & Alberta Conservation Association 2006).

In Upper Elbow River, the dominant land use includes campgrounds, equestrian, recreational vehicle use (McLean Creek), with minimal residential development (Sosiak and Dixon 2004). McLean Creek and Sylvester Creek both attract occasionally heavy recreational vehicle use (OHVs) in the public land use zone. Much attention has been paid to McLean Creek in terms of studies conducted by Cows & Fish, as well as Alberta Environment and The City of Calgary.

Treated wastewater was not discharged into the Elbow River until 2010. In previous years, many households maintained septic systems that were known to contaminate shallow aquifers and there was observed degradation in water quality downstream of Bragg Creek (University of Calgary 2000).

WATER QUALITY IN TRIBUTARIES

In total there are 19 notable tributaries flowing into the Elbow River as shown in Table 1. A number of small unnamed tributaries between the source at Elbow Lake and the Little Elbow River have not been mentioned in the literature as these are all located in Kananaskis Park Country with little or no changes in land use in this area.

The City of Calgary’s monthly monitoring program includes four tributaries: Prairie Creek, Mclean Creek, Bragg Creek and Lott Creek. These four tributaries are sampled at their mouth. Less recent studies by The City of Calgary have also included Millburn Creek (Dixon 1998).

Alberta Environment studies completed in 1993 (Beers & Sosiak 1993) and 2004 (Sosiak & Dixon 2004) included taking samples at the mouth of the Little Elbow River, Prairie Creek, McLean Creek, Bragg Creek, Pirmez Creek, Millburn Creek, Springbank Creek and Lott Creek.

Table 1: Water Quality Monitoring in Tributaries

Name of Creek	Time period*	General water quality**	Water Quality Issues
Little Elbow River	1999 – 2003	Very good	None
Ford Creek	1998 - 2001	Good	None
Quirk Creek	Not Sampled	No Data	NA
Powderface Creek	Not Sampled	No Data	NA
Prairie Creek	1998 – Present	Good	None
Canyon Creek	2001	Good	None
Silvester Creek	2001	No Data	NA
McLean Creek	1993 - Present	Fair to Good	Phosphorus, TOC nitrogen & bacteria
Ranger Creek	Not Sampled	No Data	NA
Iron Creek	Not Sampled	No Data	NA
Bragg Creek	1993 - 2012	Fair to Good	Phosphorus, bacteria, TSS
Lyon Creek	Not Sampled	No Data	NA
Harris Creek	Not Sampled	No Data	NA
Pirmez Creek	1999 - 2002	Not Classified	Phosphorus, nitrogen, bacteria
Millburn Creek	1989 - 2002	Not Classified	Bacteria, TOC, nitrogen, phosphorus,
Springbank Creek	1989 - 2002	Not Classified	Conductivity, TOC, Phosphorus
Cullen Creek	Not Sampled	No Data	NA
Lott Creek	1993 - 2012	Fair to good	Phosphorus, nitrogen, ammonia, bacteria

*Recorded sampling events only from City of Calgary monitoring data results

** Criteria based on CCME Water Quality Index and the number of guideline exceedences

Prairie Creek and Bragg Creek consistently exhibited the highest peak flows and Prairie Creek had the highest median flows (Sosiak & Dixon 2004). Some tributaries are ephemeral with intermittent flows and are likely not sampled for this reason.

Lott Creek and Bragg Creek appear to have the highest loading of total phosphorus and nitrate although the amounts vary from year to year. Pirmez Creek had the highest nitrogen concentrations and both Pirmez Creek and Millburn Creek had the highest bacterial counts of all the tributaries tested between 1999 and 2002 (Sosiak & Dixon 2004).

E.coli and fecal coliforms were found at their highest numbers in Pirmez Creek and Millburn Creek (Sosiak & Dixon 2004). It was suggested that ruminant animals and agricultural practices were the likely cause.

More recently, The City of Calgary's monthly monitoring program selected four tributaries (Prairie Creek, McLean Creek, Bragg Creek and Lott Creek) for their sampling program. Two reports have been issued for the 2007 – 2009 and 2010 – 2012 time periods. Data sheets for results between 2012 – 2014 and 2013 – 2015 are also available (City of Calgary Water Quality Data Sheets 2012 – 2014 and 2012 – 2015). The City of Calgary selected a list of 27 parameters that included organics, metals, nutrients and physical parameters, and rates each site according to the CCME Water Quality Index, which is calculated according to the scope, frequency and amplitude of the water quality objectives (federal aquatic life guideline exceedances) that are not met (CCME 2001). Results concluded that water quality was good to excellent at all four sites with exception of Bragg Creek (2007 – 2009 data) which had a result of "Fair". However, total phosphorus appears to have had consistently poor results in all tributaries tested for most of the time. Bacteria and total nitrogen also had poor results some of the time.

In summary, water quality is better nearer the head waters, with the Little Elbow River having the best overall water quality. Downstream tributaries have persistently increased levels of phosphorus, nitrogen and fecal bacteria nearer to Glenmore Reservoir. Ten out of eighteen named tributaries have not been sampled along with all unnamed tributaries. From the available literature the tributaries that have been sampled were only sampled at their confluence with the Elbow River, and no sustained sampling program has investigated and compared water quality or loading upstream with downstream values.

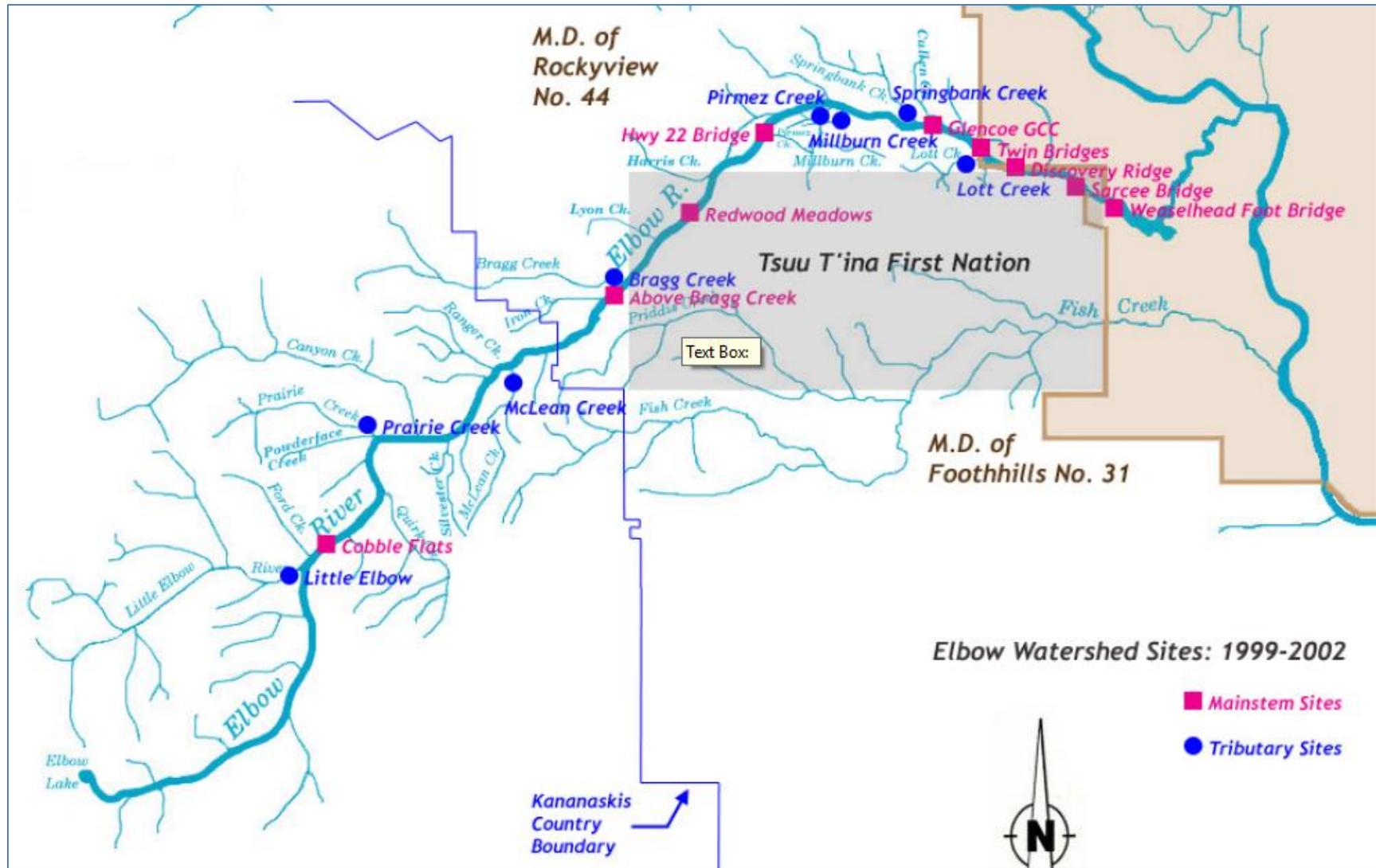


Figure 1: Map showing water quality sampling sites (Sosiak and Dixon 2004) and the tributaries (Sosiak and Dixon 2004).

WATER QUALITY IN THE UPPER ELBOW RIVER

The Upper Elbow River water quality sampling sites start at Cobble Flats and end at the Weaselhead Bridge as shown in Table 2. The City of Calgary watershed sampling programs from 2003 included six sites in the Upper Elbow River and the studies completed for the 2001 to 2003 water sampling programs conducted by Alberta Environment and the City of Calgary included nine sites. The site “Above Canyon Creek” was sampled once by The City of Calgary and not included in the joint Alberta Environment/City of Calgary Report (A. Sosiak & J. Dixon 2004).

Table 2: Summary of Elbow River Water Quality Monitoring Results from City of Calgary Water Quality Monitoring Reports 2007 - 2015

Sampling Site	Sampled	Water Quality Index	Water Quality Issues ¹
Cobble Flats	1998 to present	Good/Excellent	None
Above Canyon Creek	2001	Not Classified	None
Upstream of Bragg Cr.	1998 to present	Good	None
Redwood Meadows	2001 and 2002	Not Classified	Phosphorus, TSS,
Hwy 22 Bridge	1998 to present	Good	TSS
Glencoe GCC	1999 to 2002	Not Classified	<i>E.coli</i>
Twin Bridges	1989 to present	Good	Phosphorus, TSS
Discovery Ridge	2002	Not Classified	Phosphorus, TSS
Sarcee Bridge	2005 to present	Good	Phosphorus and TSS
Weaselhead Bridge	1991 to present	Good/Fair	Phosphorus, <i>E.coli</i> and TSS

¹ Aluminum and iron exceeded guidelines frequently and are generally considered to be naturally present and therefore not included as a “water quality issue”

Water quality results in the Upper Elbow River do appear to have changed over time for some nutrients including total phosphorus and nitrate and nitrite (University of Calgary 2015). Some water quality degradation has been apparent starting downstream of Bragg Creek with progressively increasing cumulative loading of nutrients, suspended solids and *E.coli* bacteria.

High iron and aluminum concentrations have also been noted starting upstream of the town of Bragg Creek in Elbow River, getting progressively higher in concentration in increments downstream with consistently higher concentrations up to the Weaselhead Bridge. It is important to note that no metals were sampled in the tributaries and therefore no data is available for these potential sources. It is likely however, that aluminum and iron are naturally present in the finer sediments that travel downstream to settle out in slower flowing section of the river, thus influencing the metals concentration in these downstream regions. A recent study by the University of Calgary (University of Calgary 2016) suggests that chloride increased downstream through the watershed. Chloride is a component of human and animal waste, but the source has not been determined.

E.coli was another parameter that progressively increased in number in downstream sampling sites. Literature sources from The City of Calgary and Alberta Environment reports, suggest that the highest number of *E.coli* and Fecal coliforms were between Twin Bridges and the Weaselhead Bridge. The large numbers of *E.coli* were generally attributed to non-point sources possibly from land use changes and changes in agricultural activities, with no evidence that the bacteria were of human origin through source tracking studies conducted by Alberta Environment in 2003 (Sosiak & Dixon 2004).

Ruminant markers were reported at all sampling locations in the 2004 study (Sosiak & Dixon 2004) which suggest ruminant animals are at least, a partial source of the high bacterial loading in downstream reaches of the River. Source tracking was conducted as a one-off study and results do not conclusively rule out human origin for bacteria found in the River. Studies completed by the University of Calgary in 2001 and 2002 (U of C presentation undated) suggest a relationship between coliforms, sodium, phosphorus, potassium and chloride indicating that the origin is likely from cattle and other ruminant animals.

Looking at more recent studies on the Upper Elbow from water monitoring reports from The City of Calgary, water quality in the Elbow River remains good for most parameters when summarized using the CCME Water Quality Index (WQI) (City of Calgary 2012 – 2015). However trend results (Sosiak 1999 and University of Calgary 2016) have reported increasing trends for nitrate, nitrite and total phosphorus over time. The source of these nutrients is undetermined at this time, but it is generally thought to come from non-point sources and attributed to land use changes, urban density increase and variable agricultural practices (University of Calgary 2016).

WASTEWATER DISCHARGES INTO THE UPPER ELBOW RIVER

Following reports of groundwater contamination and drinking water boil notices from private sewage disposal systems in the town of Bragg Creek (University of Calgary 2000), a new wastewater treatment plant was constructed in 2011. The new plant is a GE Membrane Bioreactor with a 1325 m³/day capacity. The wastewater treatment plant is located just off Wintergreen Road in Bragg Creek. There are no other direct discharges into the Upper Elbow, although some infiltration may be occurring through the shallow aquifer adjacent to the River from some remaining private sewage disposal systems (PSDSs). It is worth noting that the 2001 - 2003 (A. Sosiak & J. Dixon 2004) water sampling program by The City of Calgary and Alberta Environment did not find any direct evidence that contaminated groundwater from PSDSs was affecting River water quality downstream of Bragg Creek. Source tracking using PCR, of bacteria in the river did not detect any *E. coli* from human origin.

The collection and analysis of water samples from Bragg Creek by local residence with data from 2005 to the present indicate that there have been no significant changes in concentration for nitrate and phosphorus over time, although no trend analysis has been conducted on this tributary. Trend analysis and flow weighted analysis would be a more precise method of measurement to determine if water quality changes with water flows and volume.

LITERATURE REVIEW

The literature sources for this study were provided by ERWP and some information was provided from internet searches. Table 3 shows a list of historical key reports on the Upper Elbow River. The list may not be exhaustive, but covers two decades of key water quality studies that were conducted in the Elbow River Watershed. Although only a select few of the studies were referenced in this report, all studies were thoroughly reviewed and selected reports used encompassed information from previous studies.

A list of reviewed studies is provided in Table 3. This may not be a definitive list as some reports referenced material from the 1980s which was not available for review at this time.

Table 3: Upper Elbow River Summary of Reports (1990 – 2015)

Date	Report title	Subject Material	Authors
Oct-93	Elbow River Water Quality Task Force Rpt	Review of Existing Water Quality Data, standards and objectives	Elbow River Steering Committee
Jun-93	Water Quality of the Elbow River	Overview of Water Quality in Elbow River	C. Beers and A. Sosiak for Alberta Environment
Nov-98	Bacteriological Water Quality of Millburn Cr	Investigation into source of bacterial contamination	Jamie Dixon, City of Calgary
Jul-99	Evaluation of Recent Trends in water quality in the Elbow River Upstream from Glenmore Reservoir	Report on study to determine significant changes in water quality since previous study in 1988-90 (Beers & Sosiak 1993)	Al Sosiak (Alberta Environment)
Oct-99	Report of the Upper Elbow River Instream Objectives Working Group	Draft instream objectives for the Upper Elbow River	Upper Elbow River Instream Objectives Working Group
Apr-00	Water Quality impacts by Private Sewage Disposal Systems (PSDSs) in Bragg Creek, Alberta: Current Assessment and Residents' Views	Investigation into possible groundwater and surface water contamination from private sewage disposal systems in the Hamlet of Bragg Creek	A. Chu, E.A. Dixon, T. Lambert, M.I. Reid, M.C. Ryan
2004	Calgary Watershed Report 2001 - 2003	Water Quality in the Bow River watershed	City of Calgary, water Resources
May-04	Impacts on Water Quality in the Upper Elbow River	Water Quality study of the Upper Elbow River	Al Sosiak (Alberta Environment) and Jamie Dixon (City of Calgary)
Jun-05	Elbow River Instream Flow Needs Study	Hydraulic calibration of two study sites (Canyon Site & Hwy 22 Site). Calculation of instream flow needs (IFN) for fish	Golder Associates
2012	Bow Basin Watershed Management Plan. 2012	Set site specific water quality objectives for watershed management purposes – includes objectives for Elbow	BRBC Steering Committee
2009	Calgary Watershed Report: A Summary of Surface Water Quality in the Bow and Elbow Watersheds, 2007 - 2009	Results from The City of Calgary Water Resources Water Monitoring program from sampling a network of 30 stations established on rivers, streams, and reservoirs in the Calgary region	City of Calgary, Water Resources
2012	Calgary Watershed Report: A Summary of Surface Water Quality in the Bow and Elbow Watersheds, 2010 - 2012	Results from The City of Calgary Water Resources Water Monitoring program from sampling a network of 30 stations established on rivers, streams, and reservoirs in the Calgary region	City of Calgary, Water Resources
2012 - 2014	City of Calgary	City of Calgary - Water Quality Index sheets 2012 – 2014-	City of Calgary, Water Resources
2012 - 2015	City of Calgary	City of Calgary - Water Quality Index sheets 2012 - 2015	City of Calgary, Water Resources
Apr 2016	Water Quality Trend Analysis of Alberta's Elbow River Watershed from 1982 - 2015	Water Quality Trend analysis of chloride, total phosphorus, total organic carbon, nitrates & nitrites and <i>Escherichia coli</i> in the Elbow River Watershed.	Brendan Hart, Hope Husmillo, Nicloe Kukla, Maninee Kapadia, Keiran Lane-Oppenheim

RECOMMENDATIONS FOR FUTURE STUDIES

- In all the literature and reports for this study, there were no reports on water quality or hydrological studies on Elbow Lake. It is therefore recommended that seasonal water samples and flows be taken from Elbow Lake at the lake outflow to provide a basis from which changes can be assessed in the future. It would also be useful to conduct a lake water balance to assess lake volume and flows against possible future changes.
- Use continuous turbidity monitors (Sondes) to monitor heavily used sites at McLean Creek and Sylvester Creek, upstream and at the mouth of each tributary. Information from these studies would enable a better assessment of the effects of agricultural and recreational activities on the Creek and downstream in the Elbow River. The exact placing of the turbidity (Sondes) can be assessed and changed from on-site observation and results from the study.
- Assess periphyton and macrophyte biomass at selected locations such as above Bragg Creek, highway 22 bridge, and Sarcee Bridge. This will allow some degree of assessment of the effect nutrients such as phosphorus, nitrogen and ammonia is having on the long-term health of the river.
- Conduct a study on the source of increasing trends in nutrients, bacteria, organic carbon and chloride in the Upper Elbow, using mass loadings from selected tributaries and lower river reaches. Include an analysis of parameter concentrations in relation to flows and volumes to assess whether changes occur during periods of drought, or seasonal variations that can be attributed to land use practices and changes in water levels. Also include winter sampling data.
- Bacterial source tracking to assess if bacteria are from human or ruminant or other animal (including dogs and horses) should be conducted at selected locations downstream from Bragg Creek and tributaries that have been identified as containing higher bacterial numbers, such as McLean Cr., Bragg Cr., Millburn Cr., and Lott Cr.
- Create a database of all the reports completed as per Table 3 with major findings and data gaps. Manage this database as a living document and review annually to ensure gaps in information are recorded for future studies.

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