Alberta Health Services

Recreational Pool Basins Sampling Project Summary Report

September 2011

Prepared by
P Phan

Project Coordinator
D Chu

Project Sponsors
D Garchinski
N Fok

Table of Contents

List of Figures

List of Tables

1.0 Executive Summary

Environmental Public Health (EPH) of Alberta Health Services conducted a study of low-, medium-, and high-risk pool facilities in Alberta to determine the proportion of unsatisfactory results that arose from targeted sampling by department staff. EPH utilized students seconded from their environmental health practicum for one day a week over a four month period between September 2010 and December 2010.The results of the water samples taken by students were compared to results obtained from samples from operators who are required to provide regular samples via legislation. Additionally, onsite assessment forms were completed that recorded parameters including chlorine, pH and bather load to assess any relationships between such parameters and unsatisfactory results. Each facility's operator was also requested to complete the same onsite assessment form used by the students, but response was unfortunately poor from operators generally.

Analysis of the data found that the proportion of unsatisfactory results for pool samples was less than 2% of the total number of samples submitted. Of those unsatisfactory results, it appeared that operators were better sentinels for unsatisfactory water samples than the student group, which could be the result of potential variation of variables (e.g. time and location of sampling, differences in chemical parameters at time of sampling, etc.) between the two groups. It was also noted that the proportion of unsatisfactory results increased when physical parameters such as chlorine and pH were outside recommended operating levels. Finally, a statistical analysis between the student and operator sampling groups found that there is no significant difference between the two groups for identifying unsatisfactory samples.

Overall, it appears that the current regime of legislated sampling by operators is a sound quality assurance step for the maintenance of safe pool facilities. As this mandatory regime is augmented by continuing education and inspection by EPH staff, it can be assumed that there is a high level of safety for the public with respect to pools and whirlpools in Alberta.

2.0 Introduction

Recreational water environments involve a wide range of issues as they relate to health protection and prevention, including, but not limited to drowning and injury, microbial hazards, as well as concerns related to water and air quality (World Health Organization, 2006). Generally, hazards encountered in swimming pools and similar environments vary from site to site, as does the exposure to the hazards. Because the use of swimming pools is associated with benefits to health and well-being through social interactions, relaxation and exercise there needs to be a balance between the benefits of swimming pools with any potential negative health outcomes associated with such facilities. Unfortunately, the operation and maintenance of swimming pools is complex and many variables including water chemistry, disinfection chemicals and their interactions plays a significant role in reducing risk of harm to clients.

In Alberta, swimming pools are regulated facilities that fall within the jurisdiction of Alberta Health Services (AHS) for assessment of both design and operation. It should be noted that municipalities also play a role in enforcement of the Alberta Building Code through Safety Codes Officers during construction and renovations as it relates to aquatic facilities. As this paper focuses solely on the operational aspects of swimming pools under the purview of AHS, there will be no further discussion of other regulatory agencies.

The governing legislation relating to swimming pools is the *Swimming Pool, Wading Pool and Water Spray Park Regulation, Alberta Regulation 293/2006* (Alberta, 2006a) which is enacted under the *Public Health Act*, *Chapter P-37, Revised Statutes of Alberta* (Alberta, 2010). The *Nuisance and General Sanitation Regulation*, *Alberta Regulation 243/2003* (Alberta, 2003) can also apply to swimming pools if issues are not specifically defined and/or discussed within the *Swimming Pool, Wading Pool and Water Spray Park Regulation* or not. However, for the purposes of this discussion, the *Swimming Pool, Wading Pool and Water Spray Park Regulation* will be referred to as 'the Regulation.'

Within the Regulation, a "pool" means a swimming pool, wading pool, water spray park and whirlpool. As this project included only swimming pools and whirlpools, these two specific types of pools are further defined as follows:

> 1(g) "swimming pool" means a structure containing a pool of water that
>
> (i) is greater than 60 centimetres at its greatest depth, and

(ii) is used for recreation, healing, therapy or other similar purpose and means all buildings and equipment used in connection with the structure but does not include

(iii) a swimming pool that is constructed for the use of a single family dwelling unit and used only by the owners and their guests, unless the structure is operated as a business, or

(iv) a swimming pool that is drained, cleaned and filled after each use by each individual;

1(j) "whirlpool" means a structure containing a pool of water that is designed primarily for therapeutic or recreational use and that

(i) is not drained, cleaned and refilled before use by each individual, and

(ii) utilizes hydrojet circulation, air induction bubbles or hot water or any combination of them. (Alberta, 2006a)

In addition to the specific provisions of the Regulation, an additional support document also referenced within the Regulation is the *Pool Standards, 2006, for the Swimming Pool, Wading Pool and Water Spray Park Regulation* (Alberta, 2006b) which provides additional context and details of the requirements set forth by the Regulation.

The primary objective of the Regulation and the Standards is to set out requirements for swimming pools, wading pools, water spray parks, whirlpools and any fountain or artificial pond that falls within the definition of a "pool," as defined. The goal is to enhance filtration, circulation and monitoring while maintaining a minimum but effective concentration of disinfectant to provide a safe swimming environment (Alberta, 2006b). Together the Regulation and Standards set minimum standards for safe water quality and a safe and sanitary pool environment. However, higher standards may be required depending on the type and use of the pool. Ultimately, it is the responsibility of each pool owner to ensure optimum water quality and pool safety.

As a quality assurance check of the operations of pools, microbiological sampling is mandated in the Regulation, specifically Section 15, which reads,

> (1) A sample of the water in a pool must be taken and submitted to the Provincial Laboratory of Public Health (Microbiology) for microbiological testing
>
> (a) every week, or
>
> (b) at such other intervals as set out in a schedule established by the Chief Medical Officer or by an executive officer with the approval of the Chief Medical Officer.
>
> (2) If microbiological testing indicates that the requirements of this Regulation are not met, the responsible person must immediately take steps to ensure that the requirements are met.

After analysis, samples must not have a heterotrophic plate count of more than 100 bacteria per millilitre (mL), does not show the presence of *Pseudomonas aeruginosa*, and does not show the presence of coliform (Alberta 2006a). It should be noted that the results of routine microbiological results do not provide the entire picture and must always be interpreted in conjunction with chemical tests performed on-site at the time of collection and a review of maintenance records for the pool. Ongoing microbiological testing can provide valuable trend data regarding the microbial quality of the pool water as both total coliform and heterotrophic plate count are indicators of disinfection efficacy and can be used to develop a baseline trend for each pool. It should be noted that total coliform counts are also an indicator of contamination and therefore all sample results must be assessed together to obtain the most complete picture of water quality in aquatic facilities.

3.0 Objective

The objective of the study was to conduct an audit of randomly selected recreational pool basins in Alberta to evaluate pool operational variables in relation to water sampling and analysis, as well as to provide a mechanism for obtaining independent trend data for pool basin water quality. Independent samples were to be taken by practicum students employed by the Environmental Public Health (EPH) program and the results would be used for trend analysis and comparison of consistency between concurrently taken operator samples. Analysis of associated operational factors at the time of sample and comparison to established operation trends would also be conducted to identify statistically significant differences between operator sampling and student sampling. In the case of an identified difference, a field-level investigation would be initiated to provide possible explanations for the differences. Based on the data analysis and field-level investigation, potential corrective actions would be identified and implemented, as the case may be.

4.0 Methodology

There were 13 student practicum placements located at various EPH offices within AHS that began September 13, 2010. These students were temporarily seconded to the Project for one day a week over a 10-week period from September 2010 to December 2010.

4.1 Distribution by Pool Hazard Rating and Geography

Of the approximately 1650 pool basins in Alberta, the initial sample population was expected to be approximately 180 (~11% of the total) from various areas of the province. Of the 180 pool basins included in the study 60 would be high-risk, 60 would be medium-risk and 60 would be low-risk as defined by current EPH standards and/or guidelines. The classifications are based on operational challenge (i.e. simple with only one pool basin in the facility or complex with multiple pool basins and treatment systems) and contaminant potential which may either be light for infrequently used facilities such as those in apartment buildings or heavy for frequently used facilities or those with a high bather load or used by incontinent bathers such as those operated by the municipal departments (Figure 1).

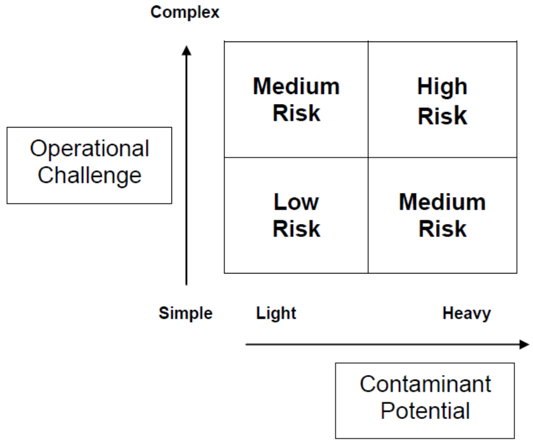

Figure 1: Risk Matrix for Aquatic Facilities (Alberta Health Services, 2011b)

The selection of pools took into account distribution of facilities that contain the pool basins geographically across the province as well as accounting for the base office of the practicum students. To tap into local knowledge and familiarity with facilities in the various zones, project coordinators in each zone of Alberta Health Services (Figure 2) were tasked with providing the final facility list for their zone (Table 1). As can be seen, the distribution of facilities across zones was not equal due to the general differences in population and facility numbers in each zone.

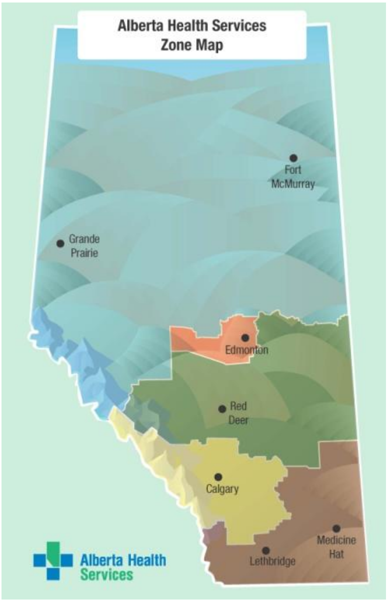

Figure 2: Alberta Health Services Zone Map

Table 1: Distribution and Type of Pool Facilities

Zone	Pool			Whirlpool		
	High	Medium	Low	High	Medium	Low
1 *South*	7	4	5	3	4	3
2 *Calgary*	19	18	8	4	3	8
3 *Central*	3	3	1	2	1	3
4 *Edmonton*	18	18	15	8	13	2
5 *North*	2	3	2	1	1	2
Total	49	46	31	18	22	18

4.2 Onsite Protocol

Each student was provided standardized training as to the proper sampling method for water samples at the outset of the project. As it is with every sample, the importance of not contaminating the sample was emphasized. Additionally, to best of their ability, students were to maintain a consistent sampling location near an outlet in the shallowest end of each pool. To ensure each sample was identified as part of the study, a highly luminous label was adhered to each sample prior to shipment. In addition to taking the sample, students were also requested to complete site assessment forms that had space to record variables such as water temperature, chlorine levels, bather load, etc. A blank onsite assessment form is included as Appendix 1 for reference.

4.3 Laboratory Analysis

Samples were taken in 200mL sterile sample bottles provided by the Provincial Laboratory for Public Health (hereafter referred to as ProvLab). Within each bottle there is a small amount of sodium thiosulfate that inactivates chlorine which provides an environment conducive to bacterial survival, if there should be any present. Samples must then be submitted with coolant and be received at the Laboratory within 24 hours of collection in order to be processed. Once received, ProvLab undertakes a presence/absence assay using defined substrate culture methods for total coliforms and heterotrophic plate count. For pools maintained at greater than 30°C, samples are also tested for the presence of *Pseudomonas aeruginosa.* All analyses performed are based on protocols described in Standard Methods for the Examination of Water and Waste Water, 21st Edition (Provincial Laboratory for Public Health, 2011). Final results were provided via regular reporting methods including electronic download via ProvLab's Electronic Reporting 4 (ER4) system.

4.4 Comparison

As a baseline to the sampling completed by the students, a comparator group comprised of facility owners were asked to continue their own regular sampling programs as per established protocols. In addition to their regular sampling regime, operators were also requested to complete the onsite assessment form, which were also submitted to EPH. It should be noted that the sampling time and location of the operators did not necessarily align with those of the students.

5.0 Results

5.1 Bacteriological Quality of Recreational Pool and Whirlpool Water

As previously discussed, pool samples for a regulated facility in Alberta must not have a heterotrophic plate count of more than 100 bacteria per millilitre (mL), must not show the presence of *Pseudomonas aeruginosa*, and must not show the presence of coliform. In the case where all criteria organisms are absent, the sample is deemed satisfactory. If any of the preceding criteria organisms are present in a sample, the sample is deemed unsatisfactory and follow-up protocols are then initiated as described in relevant EPH standards and policies (e.g. EPH Document #A-05-11-02, Actions for Unsatisfactory Bacteriological Results[Alberta Health Services, 2011a]).

Based on these sample results, it appears that operator sampling is better at detecting unsatisfactory bacteriological results than the students. The most marked difference was with whirlpool sampling where it was only through operator samples that unsatisfactory bacteriological results were reported (Figure 4 and Figure 5). When comparing the results of pools only, it can be seen that operators also had a better rate of detecting unsatisfactory water conditions (Figure 3). It should be noted however that overall the rate of unsatisfactory sample results across all facilities is relatively low (<2% of all samples).

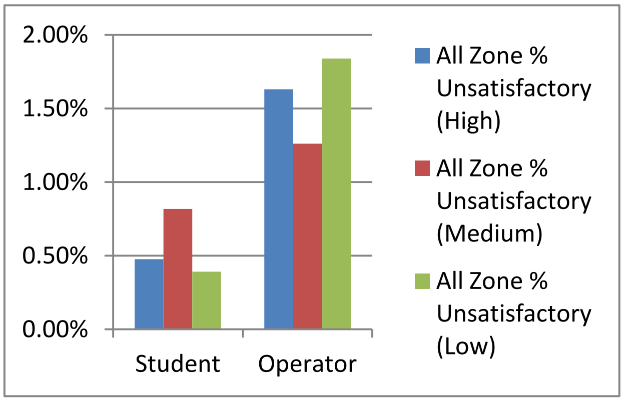

Figure 3: Percentage of Samples Considered Unsatisfactory for Total Coliforms (Pools only)

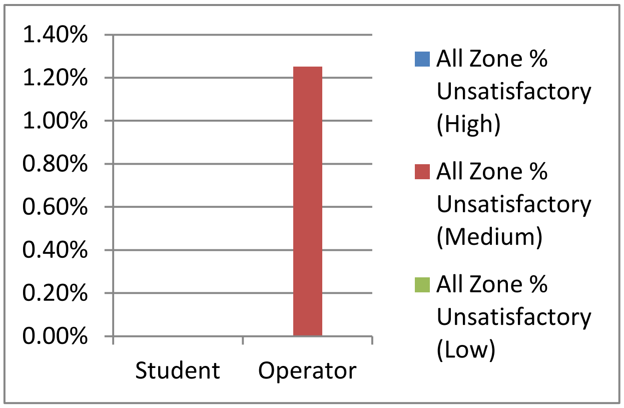

Figure 4: Percentage of Samples Considered Unsatisfactory for Total Coliforms (Whirlpools only)

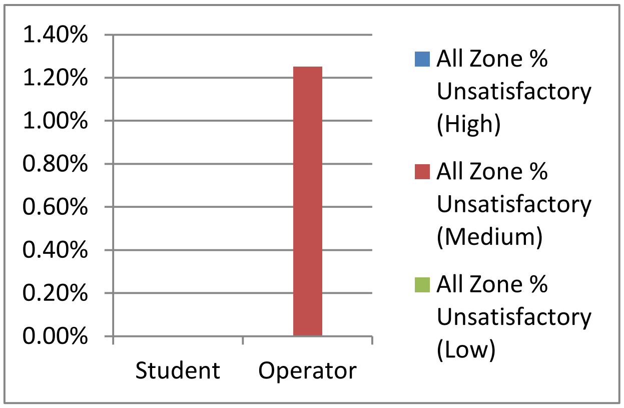

Figure 5: Percentage of Samples Considered Unsatisfactory for *Pseudomonas* (Whirlpools only)

5.2 Free Chlorine

Chlorine is the only approved disinfectant allowed for use in pools in Alberta. The disinfectant form of chlorine is "free residual chlorine" and is also known as “free available chlorine” or “free chlorine.” In Alberta, the Regulation requires pools maintained less than 30°C to have a minimum chlorine level of 1.0 mg/L or 2.0 mg/L if the pool is maintained at a temperature of more than 30°C. Furthermore, pH also contributes to the relative amounts of free chlorine available for disinfection. The effects of pH are discussed further in the next section.

For the purposes of this analysis, only student samples were used as they provided the most complete dataset. As such, peaks were observed at the intervals of 1.00 to 1.49 mg/L, 1.50 to 1.99 mg/L and 2.50 to 2.49 mg/L for unsatisfactory results. These results are not surprising given that pools operating at less than 30°C will often operate between 1.00 to 1.49 mg/L and pools operating at greater than 30°C will often operate between at greater than 2.00 mg/L. It can also be seen that High Risk facilities report higher concentrations of chlorine in conjunction with their unsatisfactory results which could be the result of higher initial chlorine levels to deal with high contaminants and/or increased bather loads. What is clear is that under-chlorination yields a significant increase in the number of unsatisfactory results (Figure 6).

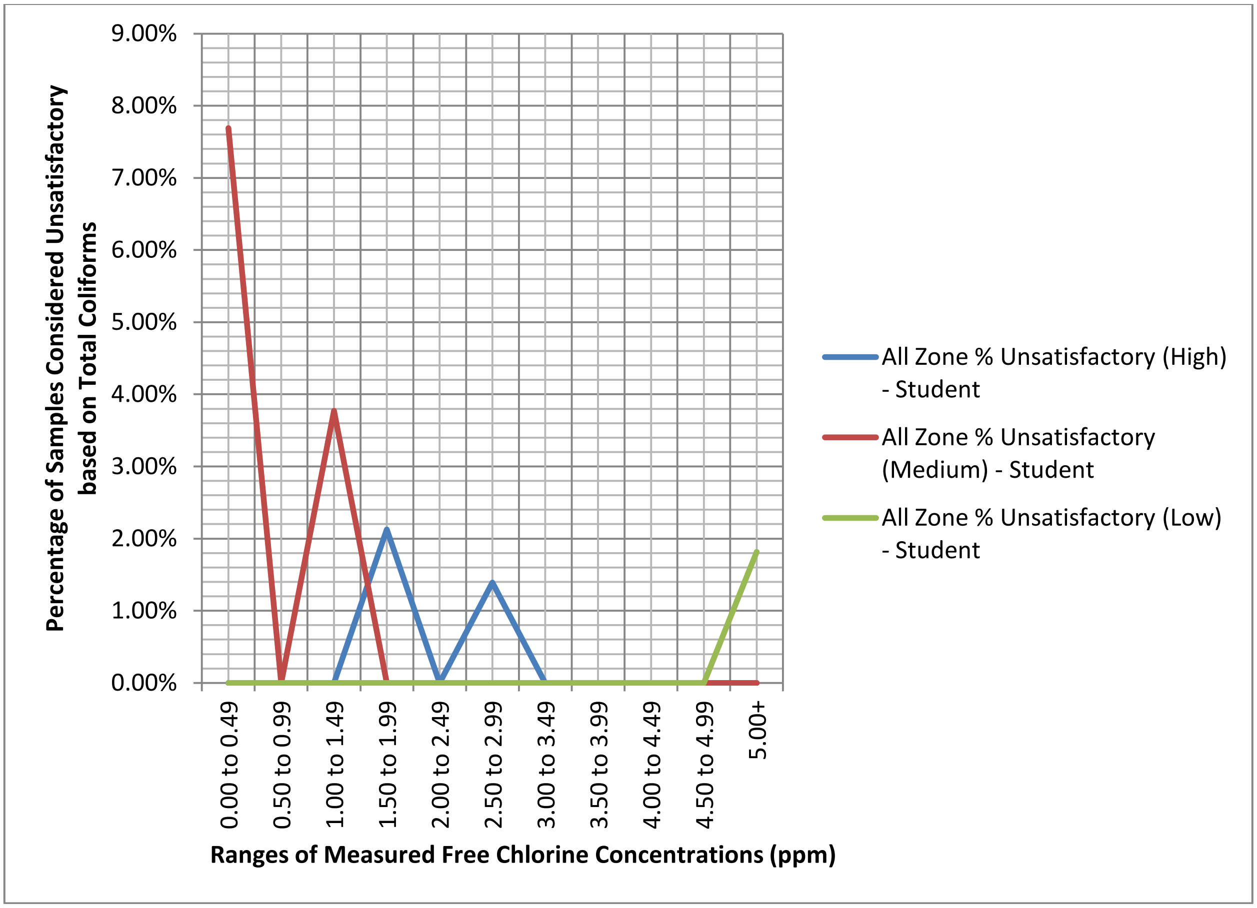

Figure 6: Percentage of Unsatisfactory Samples based on Total Coliforms as compared to Free Chlorine Concentration (Pools only)

5.3 Pool pH

As mentioned in previous section, the pH of pool water can significantly affect chlorine chemistry. The active ingredient in chlorinated water is the hypochlorous acid that exists in equilibrium with its hypochlorite ion, which is dependent on the water pH (Figure 7).

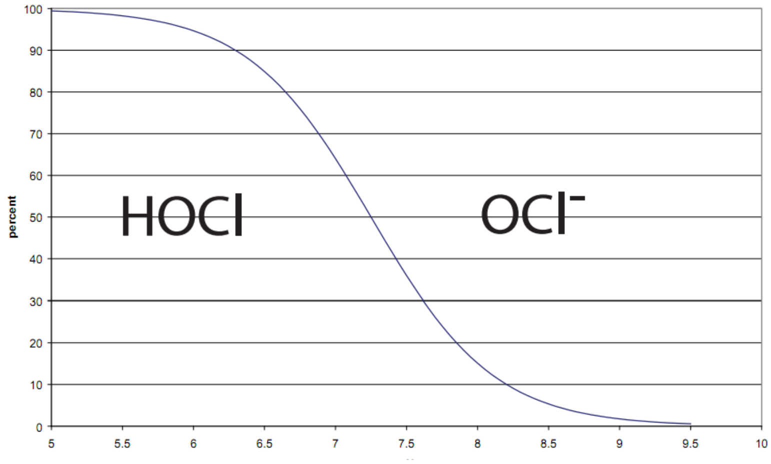

Figure 7: Percent of free chlorine in protonated form (HClO)

Beyond chlorine chemistry, pH also has additional effects of importance to pool safety. For instance, low pH can lead to skin/eye irritation, while high pH can lead to scaling water, chlorine inefficiency and also skin/eye irritation. The pH recommended for most pools is slightly alkaline which promotes bather comfort, as the pH of the human eye is about 7.5 (Taylor Technologies, 2009).

Once again, the student dataset provided the most complete reporting from the study period. Consequently, the data shows that once again the proportion of unsatisfactory samples is quite low (<1.5% of all samples). Regardless, it is evident that two peaks are observable around pH 7.00 to 7.19 and pH 7.40 to 7.59. The second peak around pH 7.40 to 7.59 coincides with the typical operational levels for pH in pools. The first peak around 7.00 to 7.19 and to a certain extent extending to 7.39 is less clear with respect to a specific reason. Some potential causes of the reported data could be misinterpretation of onsite test results or operational variances that had not been corrected by the time of sampling.

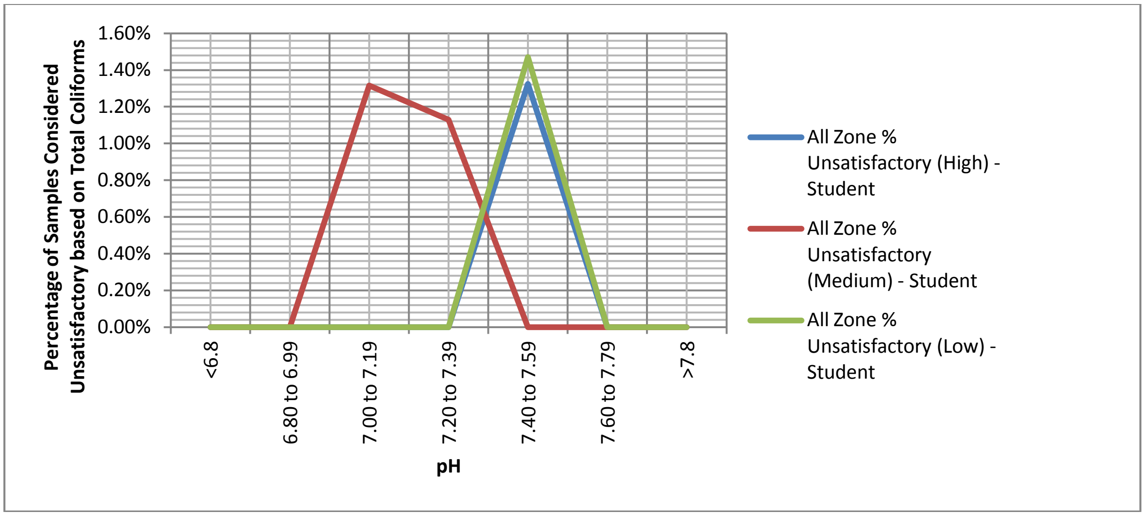

Figure 8: Percentage of Unsatisfactory Samples based on Total Coliforms as compared to pH Level (All)

5.4 Comparison of Sampling Groups

Based on the results and subsequent calculations, there does not appear to be a statistically significant difference between sampling done by students as compared to operators. To assess the similarities between the sampling groups, chi-square (χ^2) statistics were calculated where large (positive) values of χ^2 indicate evidence against the null hypothesis (H_O). In this case, the H_O is that there is no difference between the groups being compared. Further, the P-value is the probability that a χ^2 is greater than the observed statistic, so if the p-value is less than or equal to alpha, we reject H_O, otherwise, we reject the alternative hypothesis (H_A), that is, there is a difference between the groups. As such, our statistics was significantly smaller than 3.84 at α equal to 0.05, which yields a p-value greater than 0.05 (approximately 0.70 for all groups).

Table 2: Chi-square table of Total Coliforms Results comparing Students Group to Operator Group (α=0.05)

	High Risk		Medium Risk		Low Risk	
	χ2	p-value	χ2	p-value	χ2	p-value
All Zones	0.14	>0.05	0.36	>0.05	0.14	>0.05
Zone 1	0.30	>0.05	0.35	>0.05	0.08	>0.05
2	0.39	>0.05	0.35	>0.05	0.27	>0.05
3	∞	>0.05	∞	>0.05	0.38	>0.05
4	0.36	>0.05	0.50	>0.05	0.34	>0.05
5	0.28	>0.05	0.33	>0.05	∞	>0.05

Table 3: Chi-square table of *Pseudomonas* Results comparing Students Group to Operator Group (α=0.05)

	High Risk		Medium Risk		Low Risk	
	χ2	p-value	χ2	p-value	χ2	p-value
All Zones	∞	>0.05	0.33	>0.05	∞	>0.05
Zone 1	∞	>0.05	0.27	>0.05	∞	>0.05
2	∞	>0.05	∞	>0.05	∞	>0.05
3	∞	>0.05	∞	>0.05	0.40	>0.05
4	∞	>0.05	0.34	>0.05	∞	>0.05
5	0.33	>0.05	∞	>0.05	∞	>0.05

6.0 Discussion

The results of this study show that the relative proportion of unsatisfactory results across a sample population of pool facilities in Alberta is quite low (<2% of all samples). Given such a low number, operators appear to be good sentinels for indentifying unsatisfactory water conditions and do not appear to be altering or misrepresenting water samples to circumvent regulatory requirements, at least, that is detectable at a high level. This may not be the case at the individual level, but the detection of such anomalies would fall to the district EHO to identify and follow-up. When compared as a whole, operators submitted more unsatisfactory results than did the students involved in the project, especially in the case of whirlpools where only operators submitted unsatisfactory samples.

With respect to unsatisfactory results in relation to chlorine and pH levels, it is difficult to ascertain any real relationship based on these results. The only conclusion that can be made is that unsatisfactory results are less likely at typical operational levels for both chlorine and pH. The results do suggest that when parameters are outside typical levels, the proportion of unsatisfactory results increases, as can be seen for chlorine for example (Figure 6). This enforces the fact that the chemical parameters have direct effects upon satisfactory microbiological results for total coliforms, *E. coli* and *Pseudomonas.*

7.0 Challenges

Due to difficulties in logistical deployment of students and constraints of geography and time, the comparability between student and operators may be limited. For instance, there were likely differences in the conditions at time of sampling of students and operators as they did not sample at the same time. The differences in variables at the time of sampling may have impact upon the comparability of the two datasets. Furthermore, geographic density of pools heavily favoured the larger zones that have more resources dedicated to regular inspections of their pool facilities as part of regular inspection activities. As such, there was a bias towards larger centres in the selection of pool facilities that participated in the study. An additional bias that may have been potentially introduced is that operators were aware of the sampling program in advance, which may have lead to behavioural changes, for example, ensuring good water quality was maintained and/or proper sampling techniques were used in their pool facilities during the study period.

8.0 Summary

As a requirement of existing legislation and standards, operators are required to submit regular microbiological samples for assessment. Based on this project, it appears that the current sampling regime is a sound quality assurance check for the operation of a pool facility. Overall, there should be a level of confidence in operator sampling as there was difference between the two sampling groups was not significant. It is likely the observed compliance of operators in regular sampling is linked to ongoing education by EPH staff of the duties and responsibilities of operators within a regulated industry. As such, continuing education and monitoring continues to be necessary to ensure that Alberta maintains a satisfactory level of safety at recreational pool facilities.

9.0 Acknowledgements

Appreciation and thanks are extended to the practicum students who were integral to the project including Shaila Cockar, Peter Dushenski, Dominique Joseph, Jessica Lam, Sharon Lim, Carolyn Ma, Ebbinie McEachern, Claudette Parker-Allotey, Kelli Sparks, Precilla Sterling, Chai Tang, Al Verzyl and Amanda Yim. The contributions of Zone coordinators, facility operators and ProvLab who provided their collective time and expertise in ensuring the success of this project are also gratefully acknowledged as well as guidance from various members of the Environmental Public Health management team, the Aquatics Sub-committee as well as other field staff.

10.0 References

Alberta. 2006. Pool Standards for the Swimming Pool, Wading Pool and Water Spray Park Regulation (2006). Queen's Printer: Edmonton, AB.

Alberta. 2006. Swimming Pool, Wading Pool and Water Spray Park Regulation, Alberta Regulation 293/2006. Queen's Printer: Edmonton, AB.

Alberta Health Services. 2011a. A-05-11-02: Actions for Unsatisfactory Bacteriological Results. Edmonton, AB.

Alberta Health Services. 2011b. A-05-11-03: Routine Monitoring Inspection Frequency of Pool Facilities. Edmonton, AB.

Daniel, WW. 2005. Biostatistics: A Foundation for Analysis in the Health Sciences, 8th Edition. John Wiley & Sons, Inc.: Hoboken, NJ.

New South Wales Health Department. (June 1996) *Public Swimming Pool and Spa Pool Guidelines*. Retrieved on July 11, 2011 from http://www.health.nsw.gov.au/pubs/2004/pdf/poolguidelines.pdf

Taylor Technologies. 2009. Pool & Spa Water Chemistry: A Testing & Treatment Guide. Taylor Technologies: Sparks, Maryland.

11.0 Appendices

11.1 Pool Basin Field Data Sheet

Alberta Health Services

Health Protection
Environmental Public Health

Pool Basin Field Data Sheet

Part 1: Basic Information

Name of Pool Facility	Date
Description of Pool Basin (e.g. Main Pool, Slide Pool, etc.)	Time of Collection
Completed by	

Part 2: Water Quality

Water Temperature (°C)	Free Chlorine (ppm)
pH	
Has the pool undergone any chemical adjustment or addition in the past 12 hours? ☐ Yes ☐ No	
Comments/Observations	

Part 3: Bather Load

Number of People in the Water at Time of Sample	<u>Estimated</u> Number of People Within the Past Hour Prior Sample
Comments/Observations	

Part 4: Other

Comments or observations that have not been recorded in the other sections

11.2 Sample Calculations

11.3 Chi-Square Statistic

Observed for All Zones, All High Risk Facilities

	Satisfactory	Unsatisfactory	TOTAL
Student	571 (a)	2 (b)	573
Facility	643 (c)	7 (d)	650
TOTAL	1214	9	1223 (e)

Calculations for Expected for All Zones, All High Risk Facilities

	Satisfactory	Unsatisfactory	TOTAL
Student	$\frac{(a+b) \times (a+c)}{e}$	$\frac{(a+b) \times (b+d)}{e}$	573
Facility	$\frac{(c+d) \times (a+c)}{e}$	$\frac{(c+d) \times (b+d)}{e}$	650
TOTAL	1214	9	1223

Calculations for Expected for All Zones, All High Risk Facilities

	Satisfactory	Unsatisfactory	TOTAL
Student	$\frac{573 \times 1214}{1223}$	$\frac{573 \times 9}{1223}$	573
Facility	$\frac{650 \times 1214}{1223}$	$\frac{650 \times 9}{1223}$	650
TOTAL	1214	9	1223

Calculations for Expected for All Zones, All High Risk Facilities

	Satisfactory	Unsatisfactory	TOTAL
Student	569	4	573
Facility	645	5	650
TOTAL	1214	9	1223

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} = \frac{(571-569)^2}{569} + \frac{(2-4)^2}{4} + \frac{(643-645)^2}{645} + \frac{(7-5)^2}{5}$$

$$\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}} = 0.137225 = 0.14$$

Alberta Health Services