DARWIN CITY WATERFRONT WAVE POOL



OPERATION & MAINTENANCE MANUAL

POOL FILTRATION & WATER TREATMENT PLANTS

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POOL FILTRATION & WATER TREATMENT PLANTS

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1. INTRODUCTION

1.1 Forward

These Instructions are designed to assist a trained Pool Operator with the correct operation and maintenance of the filtration and pool water treatment plants that have been installed at the Darwin City Waterfront by Trisley's Hydraulic Services. These Instructions relate to the plant nominated on the Title Page and are the property of the Darwin City Council. These Instructions shall not be reproduced or used for any purpose other than originally intended without written permission of the Darwin City Council.

The Pool Operator is required to be familiar with all Instructions contained herein and to maintain this Instruction Book for immediate reference. The Manual shall not be removed from the pool premises. This Manual is not intended to be a training guide.

If the Pool Operator requires information on more fundamental aspects of operating a commercial swimming pool (eg. water testing, staff duties, legal responsibilities, emergency care, disease transmission, etc.,) the ARI Reference Handbook is recommended as a further source of information. Rather than provide specific instruction as to how to use a test kit, how to turn a valve, or when to turn an appliance on or off, these Instructions are designed to provide an overall perspective that will enable a trained Operator to properly manage the system.

Although some elements of the filtration and water treatment plant(s) are automatic, this does not imply that they will operate to their full potential without operator involvement.

This manual provides information on the filtration and chemical dosing plants only. All information (operation, maintenance, service etc) for the Wave Generation equipment is supplied in its own manual.

1.2 How to use this Manual & who does what

This Procedures Manual contains the information for a trained Pool Operator to operate and manage the various pool water treatment plants installed at the Darwin City Waterfront. It should be understood that no amount of written word could ever provide the same confidence and knowledge that can be acquired by physically operating the plant. If during the first twelve months of operation. the Operator is in any doubt, his first reference must be to Trisley's Hydraulic Services. If adjustments or revisions are considered necessary, such changes shall be approved and documented by Trisley's to be part of the project's overall Operating Instructions.

This Manual is presented in two Parts:-

Part A	Procedures Manual
Part B	Manufacturers Literature, Project Drawings, Commissioning data, Asset Register

This Procedures Manual should be read in conjunction with the results that were established during the testing and the commissioning process. The information is provided within **Part B** and provides the Operator with equipment settings that will provide the best operating results. Although the main requirement of the Pool Operator is to operate and maintain the plant in safe and efficient condition, much of this work is confined to filter backwashing, monitoring the plant controls and checking the resultant water quality. Many of the equipment settings that are established during the system's commissioning process should not be varied without the written permission of Trisley's Hydraulic Services. Again, if in doubt, the Operator should seek advice from Trisley's before making any changes.

Apart from Trisley's obligation to satisfy specific performance guarantees, they are also required to correct any defects that may become apparent during the first twelve months operation. All of the plant and equipment supplied under this Contract is subject to a standard manufacturer's limited warranty. These warranties do not allow for mis-use, abuse, failure to follow Instructions, water damage, negligence, and or accident. During the first twelve months operation Trisley's are required to provide any in-field service that may be required in order to obtain legitimate warranty replacements. **Part B** provides specific details on manufactured product.

Whilst the Pool Operator may elect to undertake some of the basic maintenance that is required to keep the plant in peak operating condition, there are items of plant that require servicing by qualified/authorized technicians. At the expiry of the defects liability period, Trisley's Hydraulic Services Pty Ltd are also prepared to offer an ongoing Maintenance Agreement through our local service agent.

1.3 Notice Regarding Guarantee

The Guarantee provided by Trisley's Hydraulic Services Pty Ltd is contingent upon all Instructions being followed implicitly. This includes the Instruction and advice provided by Trisley's staff during various training sessions.

All manufacturers and suppliers of component equipment have had formal arrangements with Trisley's to provide this project with products and services that are safe to operate and are capable of providing agreed duties. Refer to **Section 8.0** for further details on service, warranty and maintenance.

This project's primary objective has been to provide a complete pool water treatment plant that is capable of providing reliable performance and acceptable water quality. The acceptance criteria and the performance guarantees relating to Trisley's scope of works have been outlined within Instructions provided by Sitzler Pty Ltd. These Instructions were subject to a design that was provided by Geoff Ninnes Fong & Partners Pty Ltd.

The Pool Operators have a responsibility to thoroughly comprehend all aspects of the plant's operation. Throughout the defects liability period Trisley's has an equal responsibility to provide all instruction and advice that is required of them. The Pool Operator has the added responsibility to train any new staff that may be required to operate or maintain the plant. Whilst every attempt has been made to safeguard the equipment provided under this Contract, considerable risk and damage can occur if unauthorised plant access is afforded to inexperienced personnel. Access to the pool plant rooms should be controlled restricted to authorised and trained staff only.

2. THE BASICS

2.1 INTRODUCTION TO HEALTH & SAFETY

Maintaining a safe swimming pool environment involves three major responsibilities:-

- Patrons must be required to conduct themselves in such a manner as to avoid causing personal injury;
- To the best level that is possible, dirt and infective materials must be prevented from entering the pool;
- Dirt and infective material, which does enter the pool must be quickly removed and rendered harmless.

The first of these responsibilities has primarily to do with public safety as distinguished from public health. It relates to the physical conduct and deportment of individuals while at work or play within the pool areas. The disciplines for governing such behaviour have been widely studied and are taught to lifeguards and safety personnel. Since this knowledge is readily obtainable from many sources, this aspect of pool operation is expressly omitted from this Manual.

The second responsibility, like the first, involves the control of bathers. This discipline bears heavily upon the cleanliness of the bathers, the hygienic environment of the pool, and the degree of "management" imposed by the Operator.

The third responsibility involves technical knowledge, special equipment and procedures that embrace the whole science of pool sanitation and disease prevention.

To competently handle all situations, the Operator must develop a knowledge of the chemistry of swimming pool water, the mechanics of filtration, chemical feeding, and the hydraulics of the pool recirculation system.

2.2 FUNDAMENTAL CONSIDERATIONS

2.2.1 Pool Contamination

Quite often the treatment of swimming pools poses many more complex problems than those associated with drinking water. Pool sanitation in general (and water disinfection in particular) begins with bather supervision and discipline. For the most part, the rules governing good conduct

and cleanliness are pure common sense. This however does not detract from their seriousness and or the need for their strict enforcement.

Not until the Operator understands the public health involvement, can he fully appreciate the importance of insisting that patrons comply with all rules, without exception. As an example, an obviously healthy patron wearing a small bandage might seem to present an entirely harmless situation to an untrained Pool Manager. The bandage might cover the most common pimple or sore, yet the affected area might well have festered with staphylococcus bacteria. As a highly localised infection, it presents no serious problem to the person afflicted, but it poses a significant health hazard if these same bacteria are washed from the infection and taken into the system of other bathers.

Although difficult to accept, it is a fact that many overseas countries have legislation that requires nude showers with warm water and soap prior to any Pool use. Be this as it may, organic soil (usually harmless in itself) will impose a serious burden upon the chemical disinfectants and filtration system if allowed to accumulate in the pool. Simply allowing patrons to enter the pool unbathed can impair the efficiency of the disinfection system as much as 50%. Although pre-bathing is difficult to enforce, Management does have opportunities to emphasise the need that their patrons apply some common sense and have a basic respect for the welfare of other bathers. It is unrealistic to expect that any treatment system will totally solve every conceivable problem - the majority of dirt load is after all, carried into the water primarily by the bathers.

Since the contamination of the swimming pool water is inevitable, some method must be provided to treat the water and make it safe for swimmers. Such treatment is accomplished by the operation of three inter-related and interacting systems:-

- An effective means of recirculating the water through the pools that mixes the filtered water with the bather dirt load and mixes any chemicals that are added throughout the pool for sterilisation and or water balance.
- An effective system for the removal of particles by filtration.
- An effective chemical dosing programme.

2.2.2 The Recirculation System

The function of a swimming pool recirculation system can probably be best understood if it is thought of as a transportation system which takes water from the pool where it can be filtered and chemically treated and then returns to the pool. The round trip the water takes is commonly described as “turnover”. Turnover can be expressed as the number of hours necessary to recirculate a volume of water equal to the volume contained within the pool. Alternatively, turnover can be the number of times in twenty four hours that the volume of the pool is circulated, i.e. a turnover of eight hours can also be expressed as a turnover of three per day.

Turnover is only one of many considerations that is required in the design of an effective treatment system. Turnover, is however based upon the widely accepted Law of Consecutive Dilution that suggests that a turnover of six to eight hours would provide 95% to 98% dilution of soiled pool water with water that has been filtered and chemically treated.

In practice the Law of Consecutive Dilution has been largely upheld. As a minimum a 1.5 to 4 hour turnover has generally become an Industry standard for the operation of commercial pools, which are subject to variable bather loads. High density bathing simply requires higher turnover rates.

Turnover rates should always be considered in conjunction with other relevant factors that are related to total system design. This includes filter design rates (ie. m3/hr/m2), specific bather load, standard pollution (load), rated pollution load, proposed process treatment etc., etc.

Whilst it is beneficial that the Pool Operators to have an understanding of recirculation theory, a working knowledge of all flow and return lines is considered to be mandatory. If there is any doubt relating to the function and/or operation of any control valve, reference should be made to the schematic flow diagram mounted within the plant room.

2.2.3 Control of Bather Loads

The Pool Operator should be extremely conscious that water quality and recovery times are directly related to bather loads. Bather load is often explained using the “Bits of Dirt” concept, whereby it is suggested that bathers will introduce 3 to 300M bacteria (as well as fungi and virus) into swimming pools. It has equally been assessed that each bather leaves 0.5 to 1.5g or organic substances in the form of urine, skin remnants, hair, cosmetics and grease in pool water.

Whilst pool patronage in each pool will vary quite substantially, common sense dictates that bather loads should be properly controlled and managed. By keeping a meaningful Pool Log, the Operator will be able to develop a clear profile on the actual carrying capacity of individual pools. Apart from basic safety issues, over-crowding will result in poor water quality, high maintenance, and high operating costs.

2.2.4 Filtration

The removal of soiled particles by filtration is closely related to the function of disinfection by chemical treatment. However each function has a separate and distinct contribution to make to the healthy environment of the pool. These distinctions must be thoroughly understood, if the Operator is to fully comprehend the treatment of swimming pool water.

Whilst the filter plant is of some value for its capacity to remove bacteria and disease producing organisms, its primary function is to remove solids which if not removed, would increase the need for chemical treatment and reduce the germ killing and oxidising power of the disinfection chemical and/or treatment.

Filters perform their function of dirt removal through various principles, either singularly or in a combination with each other. The most apparent filtration principle is that of a screening process whereby dirt particles are separated from the liquid simply because they are too large to pass through the small openings produced in the filtering medium.

The filtration systems at Darwin City Waterfront are based on the use of UFF filtration for both pools.

2.2.5 Disinfection

While filtration is a relative simple process of physically removing solids, disinfection is a considerably more intricate process. Most commonly disinfection is accomplished by introducing a germ killing chemical to the pool water in sufficient strength to nearly instantaneously destroy bacteria. Regardless of the disinfecting agent used, the primary goal is the same; to provide uniformly distributed disinfection and oxidisation residual of sufficient strength to maintain healthy pool water.

Quite apart from any disinfection process, the oxidising properties of the steriliser also attacks many other foreign materials other than bacteria. Many of these materials, if not destroyed by oxidisation, would impart undesirable characteristics to the water such as turbidity, colour and odour. This chemical destruction plays an important part in the complete filtration and disinfection process.

Residual disinfection at Darwin City Waterfront is obtained by the use of a salt chlorination system for both pools. In addition to this there are back up dry chlorine feeders installed for both pools.

2.2.6 pH Control

pH control is possibly the least understood aspect of pool maintenance and is the most likely of the three controls to be treated carelessly or ignored altogether. The skilled Operator will be as concerned with pH control as he is with disinfection and filtration equipment.

pH is a chemical abbreviation used to describe the presence of the hydrogen ion in water. It is somewhat inaccurate to do so, but pH is more often expressed as a measure of the relative acidity or alkalinity of water. pH is measured on a scale of numbers ranging from 0 to 14. The midpoint of seven is said to be precisely neutral, above which alkalinity becomes progressively greater, and below which acidity becomes progressively greater. Swimming pool water is best maintained slightly alkaline at 7.2 to 7.8.

Problems develop when this range is exceeded on either side. A high pH, for example, can cause precipitation of dissolved minerals such as calcium and iron with resulting discolouration and turbidity.

Low pH can cause serious corrosive damage to metals within the recirculation system. Both high and low pH will cause eye irritation. From a public health point of view, the most serious effect of improper pH is the seriously reduced efficiency of some disinfection process.

Notwithstanding, pH should be strictly controlled so as to prevent, clouding and discolouration, eye irritation and serious corrosion damage.

At Darwin City Waterfront, Sodium Bi-Sulphate (Dry Acid) is used as an acid to control pH in both pools.

2.2.7 Bathing in Warm Water Pools

Whilst the pools are not mechanically heated, the Darwin facility is subject to constant high ambient temperatures. Pool Operators should be extremely conscious that these facilities require very strict management and control. In combination with high dirt concentrations and the close proximity of bathers, the risk of cross infection in warm to hot water is infinitely higher than that of a normal outdoor swimming pool. Bacteria in a warm water pool multiplies more rapidly whilst at the same time, free chlorine is more rapidly lost due to the high water temperatures and the possible aeration of the water.

2.2.8 Pool Safety Precautions

Because of elevated water temperatures, prolonged bathing should be discouraged. Elderly people or people with hypertension and or coronary artery disease should use warm water pools with great care and should never bath alone.

Given the potential liabilities that are associated with immersion in warm water, the following signage is commonly recommended:- -

(a) Pregnant women, elderly persons, and those suffering from heart disease, diabetes, high or low blood pressure should not enter the pools without first seeking medical advice.
(b) Use by children is prohibited without adult supervision.
(c) Do not use the pool whilst under the influence of drugs, medication, or alcohol.
(d) Do not use the pool whilst alone.
(e) Do not use the pool for longer than 1 hour. Long exposure to heated water may result in nausea, dizziness or fainting.
(f) To avoid injury and or discomfort, bathers should treat air nozzles and water jets with great caution (if fitted).
(g) With exposure to water temperatures at higher than 39 deg cel, hyperthermia can occur after thirty minutes of use.

2.3 OPERATIONAL REQUIREMENTS

As demonstrated during the training sessions, the Plant operation is quite straightforward. Apart from the general information outlined in other sections of this Manual**,** the Operator should be aware of the following specific factors that relate to plant operation.

2.3.1 Maintaining a Pool Log

It is essential that exact and meaningful information be strictly maintained. Such information will prove invaluable in evolving ultimate management practices and treatments. Ideally, the Operator should use a Time Management Log that effectively records operating hours; number of bathers per hour; type, consumption and frequency of any chemicals addition; all chemical levels at opening time, at mid-time and at closing time; and temperature throughout the day. If this is a problem, water quality should at least be monitored against admissions. Whilst this may not be representative of the number of bathers actually swimming in the pools, it would at least provide a very basic yardstick to monitor water quality against bather loads. The benefits of being able to anticipate bather loads and make appropriate preparations for peak use are obvious.

Reference should be made to the Northern Territory's Department of Health requirements regarding specific testing requirements and procedures. It is also important to note that:-

A sample section of a log sheet has been provided in this manual in section 8.12. The operators may wish to expand this but the headings provided are the minimum requirements for demonstrating acceptable water balance.

THE MAINTENANCE OF A LOG SHEET IS A VERY IMPORTANT TOOL FOR BOTH THE OPERATOR AND SERVICE PROVIDER. IT ENABLES THE MANUFACTURERS TO CONFIRM THAT GOOD WATER BALANCE HAS BEEN MAINTAINED IN THE CASE OF A WARRANTY CLAIM AND ALSO PROVIDES EVIDENCE THAT WATER HYGIENE HAS BEEN MAINTAINED FOR PATRONS.

2.3.2 Microbiological Testing

As outlined within the National Health's Guidelines, microbiological monitoring should be performed on a weekly basis, progressing to a regular three monthly basis, when it can be demonstrated that all management procedures are a satisfactory means of maintaining acceptable water quality.

Rather than rely on an Authority conduct such tests under the NT Public Health Act, regular microbiological testing should be commissioned by the Pool Operators and or the Owners. This service is available from any number of independent, recognised companies and it should be done at least, every three months. Microbiological Testing provides Pool Management with a clear yardstick that readily quantifies the effectiveness of any routine procedures and/or management practices. During the 12 months Defects Maintenance period, the Pool Operators are required to provide Trisley's with copies of all test results upon request. This information is required to alert Trisley's to any potential problems that could in any way be associated with the operation of the pool water treatment plant.

2.3.3 Dilution with Mains Water

European Standards require that not less than 30 litres of raw water shall be added per bather per day. Although there is no obligation to follow the overseas requirement to dump 30 litres per day per bather, the Pool Operator should be aware that a two minute backwashing of all four filters on the wave pool will consume approximately 40,000 litres of waste water, the same procedure for the Toddlers pool will consume 10,000lt.

2.3.4 Routine Vacuum Cleaning

It is imperative that any or all sedimentation be removed from the pool floor on a daily basis. Failure to remove such materials will significantly interfere with the disinfection process and radically affect water quality and appearance. Appreciating that chemical treatment is primarily designed to oxidise all unwanted matter, vacuum cleaning is best done prior to the commencement of each day's activities. Such a regime will at least address overnight sedimentation.

Please Note Carefully:-

(a) Standard Mobile Vacuum Cleaning Cart are customarily equipped with 240 Volt self priming pumps. Although such systems are normally fitted with earth leakage devices, it is important that Mobile Vacuum Carts of whatever type should NEVER be used whilst bathers are using the pool.

(b) Although automatic Pool Cleaners are available to reduce Operator involvement, most models are designed to work on random patterns, which rely on considerable operation time.

The use of automatic appliances does not necessarily obviate the need for manual vacuum cleaning. Regardless of which method of vacuum cleaning is used, it is imperative that all sedimentation be removed daily. European Standards require that pool walls be thoroughly brushed on a weekly basis and that each year the entire pool be drained and thoroughly scoured with disinfectant. Although very few Australian Centres follow this procedure, consistently high bathing loads could dictate that this procedure be adopted according to need.

2.3.5 Pool Operating Temperatures

It should be noted that temperature affects both the rate of exchange of organic matter from the human body to the water and water chemistry in general. Simply, the higher the temperature, the higher the specific dirt load. Pools should not be operated at higher than intended temperature. Apart from higher temperatures encouraging the growth of organism, other infections may be caused by the bacteria of the bathers own skin being enhanced by long exposure to warm water.

2.3.6 Pool Operator's Typical Duties

Apart from filter backwashing and some aspects in maintaining the water treatment plant (both of which are covered elsewhere in this Manual) the following requirements form part of the normal day to day requirements:-

(a) Vacuum clean pool(s) to remove all oxidised materials. Refer comments in **Section 2.3.4.**

(b) Test Pool Water (follow all instructions within your Test Kit), record test results, and make any adjustments that are necessary to preserve proper water balance.

(c) Check and log water temperatures.

(d) Check display of Indicator Lights on all Control Boards. Any abnormalities are to recorded on the daily maintenance log sheets.

(e) Check contents of all Solution Containers. Levels in each tank are to be recorded on the daily maintenance log sheets.

(f) Monitor all vacuum and pressure gauge readings. Record all pressure readings on the daily maintenance log sheets.

(g) Monitor Cl2 and pH readout(s) on all automatic controllers and compare to physical testing as required in Clause (b) - record and report any major deviations. From time to time it may be necessary to re-calibrate the chemical control probes. This change must be recorded.

(h) Check stock of chemical supply - order as necessary.

(i) Check and clean strainer baskets arranged on the suction side of the major recirculating pumps. Vacuum gauge witness connections are fitted on the pre-pump lint filters to indicate the resistance on the suction side of the pump. Any reading above -15 kPa should be promptly investigated.

(j) Conduct a visual and audible check of all items of plant and equipment. Report any water leaks as soon as they become apparent. Check that all drains and floor wastes are clear and operable.

(k) When doing a filter backwash check the effectiveness of the pump-out system. Effective

filtration is dependant upon regular and effective backwashing. This can only happen if the pump-out systems are maintained in peak operating condition. Details on the backwash pump out system is provided elsewhere in this manual.

(l) Check and clean gutter screens.

2.3.7 Plant Operation

During the training sessions provided by Trisley's Hydraulic Services, considerable effort was made to provide the Pool Operators with the opportunity to acquire "hands-on" experience and confidence in operating and maintaining the installed plant. As has been demonstrated to date, the new plant has the ability to provide exceptional water clarity with minimal reliance upon aggressive pool chemicals.

Plant operation is best outlined within **Section 7.0** where specific step by step Instructions are provided. This section provides procedures for all the major functions that will be required by the operator, cleaning strainers, backwashing, stopping and starting plants etc.

Although the installed plant is designed to be run twenty four hours per day, there are occasions where it is necessary to routinely stop the plant (eg. general maintenance, periodic service, etc.).

When stopping a pump it is necessary to follow the manufacturer's instructions. Incorrect procedures can result in excessive and unnecessary surge and water hammer that could result in considerable damage. The correct procedure to shut down or start up a pump requires that the Operator slowly closes or opens the Isolating Valve found on the pump's discharge after the pump is turned on.

Do not electrically turn-off a pump without first closing the pump's flow control valve. Do not run any pump electrically for more than one minute with the discharge valve closed. This is ample time to start or stop the pump at the Control Board. Failure to observe this requirement, will cause over-heating and possible damage to the pump seals which is not automatically covered by warranty. The filter recirculating pumps are fitted with flow switches that have run down timers set to 20 seconds.

Before re-starting any of the main recirculating pumps, double check that any isolating valves that could have been closed during a servicing operation are truly open. When restarting a recirculating pump, make sure that the Pre-Pump Strainer (which acts as a priming chamber) is fully primed with water.

Start the pump, slowly open the valve on the pump discharge - monitor both vacuum and pressure gauge pressures. Trim the discharge valve to the notch plate setting that was established during the commissioning process. This setting will provide the system's design flow.

The main pool control boards and the chemical dosing systems have electrical interconnections that are designed to fail-safe - ie., if a lack of flow were detected any associated plant that relies on

this flow will automatically shut down.

If a plant shutdown is required, the main recirculating pump(s) should be closed down in accordance with the procedures provided within this Manual. The various interlocks provided within the Pool Control Board, heating & chemical dosing systems will effectively shut down all associated items of equipment.

Individual items of plant can be isolated by turning the “ON” switch found on the Pool Control Board to the “OFF” position. All flow and return pipelines are equipped with isolating valves that should be closed in the event of a shut-down. If the Plant is to be closed down for any length of time, turn off the main isolating switches (incoming power) found adjacent to the Pool Control Board. A major plant shut down within the first twelve months of operation will require the attendance of both a Darwin City Waterfront supervisor and a technician from Trisley’s Hydraulic Services.

In the case of plantroom flooding, there are two systems installed to safeguard the installed equipment.

System 1 – This has been installed by the plumbing contractor and consists of a series of submersible pumps that are triggered by float switches located in the center drain sump. More information on this system will be in the Hydraulic Manual.

System 2 – A pump shut down system has been installed by Trisley’s Hydraulic Services. A float level switch has been installed in the center drain sump. If that switch is triggered, the electrical control board powers down all recirculation pumps & ancillary equipment. The electric actuated suction valves are then automatically closed and then the entire plant is shut down. The rationale is to protect the pumps from operating if they are submerged by water.

3.0 TECHNICAL DATA SCHEDULES

These Schedules provide quick reference to important technical details.

3.1 Wave Pool

Process Treatment	UFF
Pool Volume (m3)	2580
Design Temperature (deg cel)	Ambient
System Flow (m3/hr)	810 (225 l/sec)
Pool Turnover (hrs)	3.18
Primary Filter Area (m2)	240
No Filters/Area (m2)	4 x 60 (Atlas PCT-600)
Filter Design Rate (m3/hr/m2)	3.375
Backwash Rate (m3/hr/m2)	5
Backwash Flow/Filter (l/sec)	84
Wash Water/Filter (m3)	10 (2 minutes / per filter)
Media Charge (kg)	33

3.2 Wading Pool

Process Treatment	UFF
Pool Volume (m3)	94
Design Temperature (deg cel)	Ambient
System Flow (m3/hr)	210 (58 l/sec)
Pool Turnover (hrs)	0.45
Primary Filter Area (m2)	60
No Filters/Area (m2)	1 x 60 (Atlas PCT-600)
Filter Design Rate (m3/hr/m2)	3.5
Backwash Rate (m3/hr/m2)	5
Backwash Flow/Filter (l/sec)	84
Wash Water/Filter (m3)	10 (2 minutes)
Media Charge (kg)	33

4.0 TREATMENT & PROCESS DESCRIPTIONS

4.1 The Chlorination Process & Control Instruments

The aim of chemical disinfection is to destroy existing micro-organisms (or to at least interfere with their replication process) so that they cannot multiply. Historically chlorine is the most common disinfectant for swimming pools. Chlorine has achieved its "most commonly used" status because of its low cost, the convenience of on-site storage, and because its excess residual can persist for some time.

Refer to **Section 6.3** for a detailed description of Darwin City Waterfront chemical dosing plant. Chlorine is introduced into each pool via electrolytic salt chlorinators. The pH level, which has a very direct bearing on chlorine efficiency is automatically maintained using Dry Acid (Sodium Bi-Sulphate). Acid is injected downstream of the filtration plant (for maximum mixing and contact time) whilst Hypochlorous Acid (a result of the electrolytic reaction) is also downstream of the filters.

The water chemistry in each pool is automatically controlled via Instruments that operate with closed loop control. In this arrangement, a sample of pool water is analysed and the dosing system is regulated to maintain a particular set point. If the Instrument detects a chemical deficiency, a dosing correction is applied. The instruments provided at Darwin City Waterfront require proper calibration and regular maintenance thereafter. The instruments are not designed to replace the Operator, nor the need for regular (manual) water testing and strict management. Whilst the readings taken from the pool will not necessarily be the same as those indicated on the water chemistry Instrument, it is more relevant that there be a consistent and understood relationship between the two.

The chlorination systems at Darwin City Waterfront are controlled by Free Chlorine measurement of the pool water. The rate at which the salt chlorinators produce chlorine governed by the deviation of the sample value from the set point. With pH control the Instrument produces a current output which, activates a dosing pump that permits an acid solution to flow into the system.

The nature of closed loop control is greatly dependent upon many factors such as the representative nature of the sample water, the flow through time of the system, and the condition of the measuring electrode that is immersed in pool water. It is important to let the Instruments do their work. During the first three months of operation, changes to the set point can only be made by authorised persons. It is not uncommon for the pH of a new swimming pool to take several weeks or even months to properly settle.

4.2 Precoat Filtration

Compared to traditional sand filters, precoat filtration can provide many technical benefits by virtue of its unique “single pass” efficiency. Precoat filters provide a particle selectivity of about one to two microns and are able to remove significant amounts of small micro-organisms and bacteria. This commonly results in reduced chlorine consumption and vastly simpler pool chemistry. Unlike sand filters or other process (including ozonation with the normal 2 minute contact time) media filtration has the ability to “filter-out” modern chlorine resistant pathogens like Guardia and Cryptosporidium.

Whilst precoat filters may require slightly more operator involvement than a conventional sand filters, they are able to provide a unique and very simple process efficiency. Whilst it is necessary to replace the filter media after each an every backwash, this results in far cleaner filtration with infinitely less chance of any biological fouling within the filter vessel.

The replaceable filter media that is recommended for Atlas filters is Perlite in the form as Dicalite Grade 4156 or alternatively diatomaceous earth (Celite Grade 545) may be used. The choice of media is ultimately an Operator decision. The deployment of precoat filters can be noted by reference to the Data Sheets provided in **Section 5**. Specific product information can also be found in **Section 6.**

When handling dry filter media a disposable face mask is required. Waste filter media and collected dirt is detained within a bag filter in the plantroom, with the residual Grey water being pumped to the backwash tank for removal to sewer.

The Filter Cycle

The filter plant should be normally run 24 hours a day. The filter plant provided has been selected on the basis of the design criteria as outlined in **Section 5** of this manual. For filtration efficiency, the filter plants operate at a design flow rate of <5m3/hr/m2. This rating results in the provision of 240m2 of filter area for the Wave pool and 60m2 of filter area for the Wading pool.

For normal filtration, valves should be set as follows for UFF filters;

(1)	All filter inlet valves on the filter face plumbing are	OPEN
(2)	All filter outlet valves on the filter face plumbing are	OPEN
(3)	All backwash valves on the backwash header are	CLOSED
(4)	All filter diversion valves on the filter face plumbing are	CLOSED

If a particular filter is to be isolated, flow through the system should be decreased to suit the number of filters actually on-line. Failure to observe this instruction could adversely affect the efficiency of the filter system.

4.3 Filter Backwashing

Optimum filter performance is totally dependent upon regular backwashing at the prescribed rates. Refer to **Section 3** for the required backwash flow for each filter. Details on normal operating pressures, wash water rates, valve settings etc., are provided in the commissioning documentation in part B of this manual.

Although the frequency of backwash is load related, the Pool Operator is required to backwash the installed filters (AS A MINIMUM) at least every 4 weeks.

Note that the backwash duration on UFF filters is approximately two minutes and a one minute rinse. With experience, backwashing of the Ultra Fine Filters can be done at times that are convenient to the Plant Operator. Each backwash must be faithfully recorded in the Plant Log Book and on the blackboard on the side of the filters. Backwashing of the filters is preferably carried out at or near the end of the day's activities. Given the amount of make-up water that is inevitably required after backwashing, this gives the pool a greater recovery time to process the raw mains water.

4.4 Disposal of Wash Water

All wastewater eventually ends up in the backwash tank located adjacent to the plantroom. An automatic pump out system sends this water to sewer at a rate of 2 lt/sec. At regular intervals (say every 6 months) the backwash tank will need to be emptied of built up solid matter. A vacuum tanker contractor should be engaged for this process.

4.5 Pumping Equipment

Given that recirculating pumps are responsible for maintaining the flow through the treatment plant they are often considered to be the "heart" of the system. Whilst pumps create the flow, all other items in the recirculation system provide resistance to this flow. For this reason, pumps must not only furnish the required flow, they must do so with enough force to overcome the resistance of items like pipework, valves, and filters etc., that are an inherent part of the system.

The recirculating pumps at Darwin City Waterfront are centrifugal pumps, where typically the flow varies according to the resistance that they are required to operate against. In the case of the pools, pumping capacity is provided by full-duty pumps. This provides greater flexibility and provides the Operator with a simple mechanism to manage the pool's energy requirements according to actual loads and conditions.

Since the performance of any centrifugal pump has two dimensions - "flow" (normally expressed as litres per second) and "pressure" (normally expressed metres head), a correct definition should always provide reference to both parameters eg., x flow at y metres head.

Operators should remember:

the higher the pressure; the lower the flow, and conversely,

the lower the pressure; the higher the flow.

In operational terms, when the filter is dirty the resistance to the flow will be at it highest and the resulting flow will be at its lowest. Cleaning the filter lowers the filter pressure and increases the system's flow. It should be noted that a pump's power consumption increases as the flow increases. When a filter is clean, it is producing a high flow and therefore consuming maximum power. As the filter becomes dirty, the flow rate decreases and the power consumption decreases proportionally. Contrary to popular belief the least amount of power is consumed when the pump discharge valve is completely closed with zero flow and maximum pressure upstream of the closed valve.

Each pool's turnover has been commissioned on the basis that the system flow occurs at a point half way between a clean and dirty filter. To provide the required flow, the manual flow control valve provided on each pump discharge has been set and marked during the commissioning process. This simple valve (on the pump's discharge) plays a very important part in managing the system's flow and should not be adjusted or changed without reference to Trisley's Hydraulic Services.

Pump flows can be diagnosed by consulting the vacuum and pressure gauge readings against a certified pump curves. A vacuum gauge reading higher than - 25 kPa should be immediately investigated on the basis that it implies a resistance on the suction side of the pump, eg., a line blockage, a dirty pre-pump strainer, an inadvertently closed or restricted suction valve.
To protect the internal workings of the pump, all recirculating pumps are arranged with Pre-Pump Lint Filters that feature quick action toggle bolts for easy access to perforated strainer baskets. Refer to **Procedure 7.7** for details on cleaning the pre-pump strainer.

4.6 Pool Heating Systems

The pools at the Darwin City Waterfront project operate at ambient temperatures.

4.7 Control Systems

The Pool Control Board within the plant room connects the incoming supply and distributes the required power to all electrical equipment provided under the Contract.

Whilst the Pool Control Boards provide power to ancillary equipment, flow switches have been installed which will prevent power being supplied to the Chemical Dosing plants.

The operation of all main recirculating pumps is electrically interconnected with the chemical dosing plant such that chemical dosing can only operate when water flows through the system. If a recirculating pump fails to produce sufficient water flow, or fails to adequately "make and hold" the associated plant will automatically shut down and display a fault.

Indicating lamps are provided on the Pool Control Board to demonstrate operating status of all main pumps. The flow through each pool system has been determined by volumetric analysis and gauge readings against a certified pump curve.

5.0 SYSTEM DESIGN

5.1 Introduction

The filtration and water treatment plants installed by Trisley's Hydraulic Services are designed to provide optimum water quality. They are also designed to reduce the liability of random breakdowns and equipment failures. Wherever practical, valves and controls have been installed at an accessible height.

5.2 Description of the Operating System

5.2.1 Process treatment for the Wave pool

* Collection of soiled surface water via perimeter wet deck grating and side skimmer grates.
* Discharge of soiled surface water into dedicated balance tank that is equipped with overflow and make-up provisions.
* Direct suction from the balance tank.
* Screening of all soiled water through pre-pump strainers.
* Filtration through bank of UFF filters that are equipped with dedicated pump sets and face plumbing for reverse type backwashing.
* Correction of high pH levels via the injection of dry acid.
* Residual disinfection with controlled dose of Hypochlorous generated by electroclytic salt chlorinator which is regulated by a Free chlorine controller.
* Metered control of filtered and chemically treated pool water to strategically placed floor nozzles located within the pool.
* Water Make-up and overflow provisions are installed in the balance tank.
* Complete scheme controlled via manual valves and dedicated Control Board complete with necessary interlocks, controls and alarms.

Process Treatment for the Wading Pool

* Collection of soiled surface water via perimeter wet deck grating.
* Discharge of soiled surface water into dedicated balance tank that is equipped with overflow and make-up provisions.
* Direct suction from the balance tank.
* Secondary screening of all soiled water through pre-pump strainer.
* Filtration through a UFF filter that is equipped with dedicated pump set and face plumbing for reverse type backwashing.
* Correction of high pH levels via the injection of acid.
* Residual disinfection with controlled dose of Hypochlorous Acid that is regulated by a Free chlorine controller.
* Metered control of filtered and chemically treated pool water to strategically placed floor nozzles located within the pool.
* Water Make-up and overflow provisions are installed in the balance tanks.
* Complete scheme controlled via manual valves and dedicated Control Board complete with necessary interlocks, controls and alarms.

Pool balance tanks are fitted with automatic level devices. All operating levels have been carefully established and have been set during the commissioning process. These settings should not be changed without approval from Trisley's Hydraulic Services.

6.0 EQUIPMENT DESCRIPTIONS

6.1 Precoat Filters (UFF)

All pre-coat filters used on this project are manufactured by Atlas Australia. Atlas filter shells are fabricated from heavy gauge 316 Stainless Steel in accordance with specific Standards and References. The filters have in addition been coated with a Glass Flake Vinyl Ester coating for additional protection from the salt water environment. The Atlas brand that has been used on the project has NSPI (National Spa & Pool Institute, USA) approval as well as other design awards. The filters are a proven product in commercial pools and will provide excellent durability for the operator.

The filter elements inside an Atlas filter are injection moulded from ABS and are covered with a special filter fabric that is 100% monofilament polyethylene/polyester. The filter fabric is heat set during fabrication to provide perfect support for the replaceable filter media. The filter elements are held in place by o'rings at the head of the element. The filter elements are spaced to minimise bridging during the filter cycle. This unique element spacing also enhances the efficiency of the backwash cycle.

With regard to the filter's connections, soiled water enters the side of the filter that creates a strong swirling motion. This ensures that the filter elements are uniformly coated with the replaceable filter media that is added at the start of each filter cycle.

By operating the valves installed on the filter, water enters at the bottom of the filter with a upward type flow. As water is forced inside the filter elements, the supporting filter cloth balloons outwards causing the filter media to be discharged through the backwash line. This is called the upper backwash cycle. The valve arrangement is normally in the filter position. Another valve arrangement allows for a lower backwash (or rinse) cycle to be carried out.

The lower backwash cycle (or rinse) is carried out after a normal backwash cycle. This enables any remaining solid material to be evacuated from the filter chamber. Once this has been carried out, the filter can be placed back into filter mode and the filter pre-coated with DE powder.

Note that precoat filters have no need for any coagulants or floccing agents, and in fact, the use of any such material will result in extremely short filter cycles, blocked filter elements, and major service problems.

6.2 Electrical Control Systems

6.2.1 Introduction.

- Operators should never open any control panel unless a qualified service technician is present.
- Any adjustment of any instrumentation must be noted on the plantroom log sheets.

6.2.2 Electrical Control Boards. (ECB)

The facia panel on the ECB allows for the operation of all electrical equipment. A run meter is supplied for each main recirculating pump so that proper service procedures can be followed. Starters are provided for the various boost pumps and ancillary equipment.

The important function of the ECB is to integrate the actions of the pumps with the heating and the chemical dosing systems. If a lack of flow is detected, a series of electrical interlocks will automatically shut down specific/related plant. Each recirculation pump has a flow switch installed that detects water flow and provides a running signal to the main electrical control board. If there is no flow the pump will shut down after 20 seconds. They in turn are interlocked to the chemical control systems.

6.2.3 Remote Panel

The electrical control board has volt free contactors available so that if required in the future, a remote control panel could be fitted.

6.3 Chemical Control System

6.3.1 Introduction

Water treatment at the Centre provides primary disinfection and oxidation with salt water electrolytic chlorinators (which produce Hypochlorous Acid). Sodium Bi-Sulphate is used for pH correction in both pools.

6.3.2 Hypochlorous Acid

The pools utilize salt chlorinators that produce Hypochlorous Acid as the primary sanitizing agent. This equipment is installed within the plantroom on the mezzaniene level.

All chlorine systems are operated with Free Chlorine controllers and electronically controlled systems as generally outlined within **Section 4.1**. The installed systems will automatically increase or decrease the amount of chemical injected into the water according to the bathing load. The levels are preset and should not be adjusted without a supervisor’s knowledge and any such change is to be registered in the log book.

In addition to the salt chlorinators, a dry chlorine feed system has been installed as a “back up” in case the primary chlorination system fails, requires service etc. Information on these units are provided in the manufacturers manuals.

6.3.3 Dry Acid (Sodium Bi-Sulphate)

The Centre has dedicated bulk storage area for acid. This area is located in the plantroom. A diluted acid solution is injected into the system via a controlled dosing pump. Attention to all material safety data sheets and Workcover procedures are to be kept in mind when filling the storage tank.

7.0 OPERATING PROCEDURES

The following Procedures should be used in conjunction with the advice and physical Instruction that was provided during numerous training sessions. During the first twelve months of operation it is a condition of Warranty that all Plant Operators have been trained by either Trisley's Hydraulic Services or by a member of Darwin City Waterfront Wave Pool Centre staff who are suitably qualified to operate the plant.

If future staff changes dictate that further training is required, this service is available from Trisley's or our local service agent on a commercial hourly rate basis. These procedures should also be read in full context with all other Instructions provided within the various Volumes that form part of this Manual.

7.1 Preparation for Plant Start-Up

This procedure should be used when there is a need to restart the plant after a pool shut down, or after there has been an interruption to the main power supply, etc., Each of the steps within this Procedure must be checked and witnessed by a second Operator, ie, the plant should never be started by just one person.

The preparatory procedures for plant start-up are:-

- All switches on the electrical control board must be switched to the OFF position
- All main isolating valves must be fully opened (ie; both flow & return lines) (N/O)
- All filter inlet valves to be open (N/O)
- All filter outlet valves to be open (N/O)
- All pump discharge valves to be closed (N/C)
- All filter diversion valves to be closed (N/C)
- All filter backwash valves to be closed (N/C)
- All ancillary valves for chemical dosing, feature pump & boost pumps etc., are closed

VALVE LABEL LEGEND

N/C – NORMALLY CLOSED
N/O – NORMALLY OPEN

7.2 Bringing the Pre-coat (UFF) Plant Back On-Line

Before bringing the pre-coat systems back on-line double check that all main isolating valves are truly open and that the position of the valves on the filters are set in “filter” mode. The procedures are:-

1. Start filter pump and slowly open pump discharge valve. Remember the “No Flow” Flow Switches are set for 20sec.
2. Check over system to ensure operating correctly
3. Bleed out any air through top air release if required
4. Repeat steps 1,2 & 3 for each filter until the plant has reached the desired flow rate
5. Open valves to sample cells for chemical dosing
6. Start up & open boost pumps and any other equipment offline

The pre-coat filter should now be operating and filter pressures will come up to the normal operating conditions. Monitor all pressure and vacuum gauges, during this procedure. Abort the procedure if any anomalies are detected and double check for possible problems such as wrong valve status etc. Do not proceed if there is an inherent fault or if the Operator is not totally comfortable with the conditions and or the operations. In the latter case, seek phone help!

7.3 Backwashing UFF Filters

The frequency of backwashing can be controlled by using three criteria;

Load related
The Pool Operator should backwash the filters when the filter pressure differential exceeds 50kpa on a regular basis. The operator should be re-generating every 2-3 days to extend the filter cycle but once the 50kpa differential recurs after say 2 days, the filters require backwashing.

This is the preferred method as it provides maximum efficiency for the filter media and uses the least amount of water.

Time related
The operator can carry out a backwash after say every three weeks. The timing should be reviewed if the filters are still performing well as this method will consume more waste water.

TDS related
As solid particles, contaminants & chlorine are added to the water, the TDS level will rise. It is industry practice to dump pool water if the TDS level in the pool rises 1500ppm over the incoming level of TDS in the mains water.

When the UFF filters become dirty, the pressure gauge found on the individual filters will indicate a pressure rise above the clean start-up pressure. The pressure rise for backwashing should never consistently exceed 50 kPa above the clean start-up pressure.

- Select the filter to be backwashed according to an approved timetable/schedule.

- Record the filter's operating pressure in the Log Book

- Check backwash tank indication light is ready ***(green light)***

- Shut down the pump on the filter to be backwashed. ***(Refer to specific procedures)***

- Set the filter valves to the backwash position.

Filter Inlet	CLOSED
Filter Outlet	CLOSED
Diversion	OPEN
Backwash	OPEN
Isolation	OPEN ***(Wading Pool Only)***

- Turn on the filter's recirculation pump & open the pump discharge valve. The filter is now backwashing. The backwash cycle should take approximately 2 minute. Backwash until wastewater in backwash sight glass becomes clear or for at least 2 minute.

- Isolate pump discharge valve & turn pump off

- The waste wash water is discharged to the main backwash tank.

- The backwash procedure has now been completed. Set the filter valves as per **7.4 Lower Backwash Procedure *(Rinse Cycle)***

7.4 Lower Backwash Procedure (UFF Filters)

After the backwash procedure is complete, the filter should be rinsed to flush any spent DE powder out of the tank. This is called a lower backwash. The procedure is as follows;

- Select the filter for a lower backwash
- Ensure the recirculation pump is shut off
- Set the filter valves to the lower backwash position

Filter Inlet	OPEN
Filter Outlet	CLOSED
Diversion	CLOSED
Backwash	OPEN
Isolation	OPEN ***(Wading Pool Only)***

- Turn on the recirculation pump & open pump discharge valve. The filter is now rinsing. The rinsing cycle should take approximately 1 minute. Rinse until wastewater in backwash sight glass becomes clear or for at least 1 minute.

The solid waste will be sent through to the backwash tank. The backwash water will now sit in the tank allowing the DE to separate from the water before the sump pump activates and empties the tank through the DE Separation Tank.

- Isolate pump discharge valve & turn pump off
- Press the De Separation Pump start button on the wall, ensure valves are open *(pump is on a 24hr delay start timer)*
- The rinse procedure has now been completed. Set the filter valves as per **7.5 Vacuum Feed System for Precoating UFF Filters**

7.5 Use of the Vacuum Feed system for Pre-coating UFF Filters

After the lower backwash procedure is complete, the filter should now be backwashed & rinsed with all spent DE powder out of the tank. This filter is now ready for the Vacuum Feeding of the DE call Pre-coating.

The procedure is as follows;

- Ensure the recirculation pump is shut off

- Set the filter valves for the draining prior to the Pre coating

Diversion	CLOSED
Filter Inlet	CLOSED
Filter Outlet	CLOSED
Backwash	OPEN
Filter Air Release	OPEN
Drain Line	OPEN

- Let filter completely drain out through Drain Line located on Backwash Line at rear of Filter 5.

- When the filter is completely empty,

Diversion	CLOSED
Filter Inlet	CLOSED
Filter Outlet	CLOSED
Backwash	CLOSED
Filter Air Release	CLOSED
Drain Line	CLOSED

- Open the Filter media box and cut open the inner plastic bags.

Note: Each filter requires 33kgs of filter media.

- Connect Vacuum Hose to De Feed Valve

OPEN

Vacuum suction Valve *(Yellow Pipework)*
DE Feed Valve *(Cam-lock Fitting)*

- Open and check Vacuum Filter Cannister, clean out & dry any water from inside prior to operating. Close drain valve on DE Vacuum line.

- Start up the blower and vacuum the filter media from the bag/s.

NOTE - To operate blower behind wading pool pump/filter, you will need to isolate & turn off as an electrical interlock does not allow it to operate if this pump/filter is running

- When all the filter media has been educted into the filter

- Clean-up any mess, vacuum the floor using the clear hose if necessary.

- Turn off vacuum/s at switches

CLOSE

Vacuum suction Valve *(Yellow Pipework)*
DE Feed Valve *(Cam-lock Fitting)*

- Remove Vacuum Hose from De Feed Valve

- Open drain valve on DE Vacuum Line

The pre-coating process is now complete and you can start up the filter as per normal procedures.

The replacement of the filter media, after each and every backwash, is a condition of warranty. Failure to replace filter media after backwashing will damage the filter candles and result in expensive and unnecessary service.

It is important to use the prescribed quantity of filter media. Adding more than the required amount will only shorten the filter cycle. Adding less filter media will cause long term damage to the filter's internal elements. When handling dry powdery media's, the operator is required to wear an approved dust mask.

Note and record the filter's new pressure gauge reading in the Log Book.

7.6 Emergency Shut Down

In an emergency situation, disregard all protocol and turn off the main switch on the ECB.

Although the need for an emergency shutdown is unlikely, possible reasons could include a major malfunction with plant and or equipment, plant room flooding, etc., An emergency shut down as a harsh procedure and it should not be undertaken without due need.

7.7 Cleaning Pre-Pump Strainers

Under normal operating conditions, the vacuum gauge reading on the pre-pump strainers should be somewhere between 0 to - 25 kPa. Readings will vary depending upon the amount of debris collected within the strainer. As debris is collected in the strainers the vacuum pressure will rise. Any vacuum reading above - 25kPa should be immediately investigated. Rather than rely on vacuum gauge readings, all pre-pump strainers should be cleaned on a weekly basis.

Whilst it is not essential to manually shut down the related plant *(eg:- Chemical Dosing Plant, etc)* the Operator should physically and routinely check that this does occur when the re-circulating pumps are shut down. This check will confirm that the flow switches and the various plant interlocks are fully operational. The pre-pump cleaning procedure is as follows:-

- Close the pump discharge valve. Once the valve(s) have been closed, switch off the pump at the remote stop/start switch ***(located beside each pump).*** An electrical interlock in the ECB will automatically switch off all ancillary equipment if you turn off ***all*** pumps. Ensure all ancillary equipment has turned off in this situation.

- Close actuator Pump Suction Valve by hand by adjusting the switch from automatic to manual and then turning the wheel till closed.

- Open the air release on the strainer lid.

- Open the drain valve located under the strainer.

- Undo the strainer's toggle bolts; remove the lid; lift out and clean the basket of any debris. Note even small amounts of debris can detract from pump performance. The size and area of this basket has been designed for minimum pressure drop. Do not expect the basket to be full of debris. This should never be allowed to happen!

- Make sure that the Lid ‘O’ ring seal is completely clean, replace the basket, refit the strainer’s lid and secure the toggle bolts. Make sure that the lid is properly seated and fastened down. Do not over-tighten or force the toggle bolts. If a problem is encountered, check, clean, and or replace the o ring seal.

- The installation is of a “flooded suction” design, which should keep the strainers full of water. If the strainers drain out, this will mean that the suction line is either blocked or there is insufficient water in the balance tank. A service is recommended if this happens. The recirculation pumps need to be primed for the pumps to work properly.

- Open actuator Pump Suction Valve by moving the switch from manual to automatic, the valve will automatically reopen.

- Bleed air out through air release valve, close when air is removed from strainer.

- When convinced that the pre-pump strainer has been primed, start the recirculation pump and gradually open the pump discharge valve to the notch plate setting that establishes normal full flow. Progressively start other pumps in the same fashion. Ancillary equipment within this circuit will be brought on line automatically. Carefully monitor all gauge readings throughout this step and check for any anomalies.

- Check all ancillary equipment has restarted.

7.8 Placing the Precoat (UFF) Filters in Normal Filtration Mode.

The UFF filter systems have a series of valves fitted that enable the filters to be placed in either a filter, backwash or rinse mode. Valve markings are as follows;

FILTER INLET	Allows water to enter through the bottom of the filter to commence the filtering process.
FILTER OUTLET	Once water has been filtered it leaves the filter via this valve.
FILTER DIVERSION	This valve is used to direct water for either filtering, backwashing or rinsing.
BACKWASH	Used to allow water to escape to the backwash holding tank in either backwash or rinse mode.

NOTE
After performing a backwash, open the filter inlet & outlet valves on the filter to allow water to enter prior to starting the pump back up. Water will start to fill the filter, utilize the air releases on the side and top of the filters to bleed any excess air. Once you have enough water in the filter you can restart the pump ***(as per 7.2Bringing the Pre-coat (UFF) Plant Back On-Line)***

7.9 Cleaning the DE Separation Bag Filter

The solid waste from the backwash water will now sit in the tank allowing the DE to separate from the water before the sump pump activates and empties the tank through the DE Separation Tank.

Most of the DE will remain in the Backwash Tank and will require to be pumped out on a regularly basis ***(at least annually)*****.** The removal and disposal of spent DE will need to be performed by an accredited qualified waste removal company.

Once the pump has emptied the water from the backwash tank you will need to empty the De Separation bag of any excess DE.

- Ensure pump is turned off
- Close all isolation valves on system
- Open the air release on the separation tank lid.
- Undo the separation tank's toggle bolts; remove the lid; lift out and clean the bag of DE. Dispose of any excess DE from bag.
- Replace the bag and re-secure the lid with the toggle bolts.
- Close the air release on the separation tank lid.
- Open all isolation valves on system

The system is now ready for the next backwash cycle.

7.10 Salt Chlorination – Acid Cleaning Procedure

7.10.1 Overview

Depending on the water hardness, salt quality and duty cycle of the machines it is expected that acid cleaning will be required once every 2 - 6 months ***(Wading Pool machine)*** and once every 7 – 21 days ***(Wave Pool machine).***

Make up a solution of 5 % Hydrochloric Acid in the acid cleaning tank by adding concentrated HCl **(30 – 35 %)** to water in the ratio 1 part acid to 5 parts water. i.e. add 10L HCl **(30 – 35 %)** to 50L water. Always carefully add acid to water and make sure all relevant safety procedures are followed.

Note:
This procedure must be carried out with care in a well ventilated area. Read and observe the relevant Material Safety Datasheet ***(MSDS)*** and always wear Hydrochloric Acid resistant protective clothing, gloves, a face shield and mask. Observe all relevant OH & S procedures.

Note:
Before acid cleaning ensure acid cleaning tank is at 200L mark.

Note:
The electrolyser cells must never be energized when acid cleaning is in progress or when any acid is present in the cells.

Note:
Never leave 5 % Hydrochloric Acid in contact with the cells for any more than 30 minutes or permanent damage to the electrodes may occur.

7.10.2 Acid Cleaning Procedure – Wading Pool Salt Chlorinator

1. Make sure acid cleaning tank is at 200L mark
2. Turn off power to cells on wading pool chlorinator control board
3. Turn off power to cells on wave pool chlorinator control board
4. Turn off wading pool chlorine boost pump on main pool ECB
5. Turn off wading pool salt chlorinator on main pool ECB
6. Turn off wave pool chlorine boost pump on main pool ECB
7. Turn off wave pool salt chlorinator on main pool ECB
8. Slowly close control valves V1 and then V2
9. Fit drain assembly to drain line
10. Drain the cells by opening drain valve V3 and then vent valve V4 to allow the water to drain from the system
11. Once the cells have drained close drain valve V3 and then vent valve V4
12. Open acid inlet valveV5 and acid return valve V6
13. Turn on acid cleaning pump switch ***(located adjacent to acid cleaning pump)***
14. Activate acid cleaning pump by pressing the green "on" button on acid cleaning pump control box
15. Allow the acid to circulate for 10 – 20 minutes during which time all calcium and magnesium deposits should dissolve. **Note:** Return to the acid cleaning tank to check that acid is returning to the tank
16. Turn off acid cleaning pump by pressing the red "off" button on the acid cleaning pump control box
17. Turn off acid cleaning pump switch ***(located adjacent to acid cleaning pump)***
18. Close acid line valves V5 and V6
19. Slowly open valve V2 and then V1
20. Turn on wading pool chlorine boost pump on main pool ECB and wait for 2 minutes to allow acid to flush through the system
21. Turn on wading pool salt chlorinator on main pool ECB
22. Turn on wave pool chlorine boost pump on main pool ECB
23. Turn on wave pool salt chlorinator on main pool ECB
24. Turn on power to cells on wading pool chlorinator control board
25. Turn on power to cells on wave pool chlorinator control board
26. Log Acid Cell Cleaning onto your Daily Log Sheet

Note:
Wading Pool cells have now been acid washed. Both Wading Pool Salt Chlorinator and Wave Pool Salt Chlorinator are back on line

7.10.3 Acid Cleaning Procedure – Wave Pool Salt Chlorinator

1. Make sure acid cleaning tank is at 200L mark
2. Turn off power to cells on wave pool chlorinator control board
3. Turn off power to cells on wading pool chlorinator control board
4. Turn off wave pool chlorine boost pump on main pool ECB
5. Turn off wave pool salt chlorinator on main pool ECB
6. Turn off wading pool chlorine boost pump on main pool ECB
7. Turn off wading pool salt chlorinator on main pool ECB
8. Slowly close control valves V1 and then V2
9. Fit drain assembly to drain line
10. Drain the cells by opening drain valves V7, V8, V9, V3 and then vent valve V4 to allow the water to drain from the system
11. Once the cells have drained close drain valve V7, V8,V3 and then vent valve V4 leaving V9 open
12. Open acid inlet valves V5, V12 and acid return valve V6
13. Turn on acid cleaning pump switch ***(located adjacent to acid cleaning pump)***
14. Activate acid cleaning pump by pressing the green "on" button on acid cleaning pump control box
15. Allow the acid to circulate for 10 – 20 minutes during which time all calcium and magnesium deposits should dissolve. **Note:** Return to the acid cleaning tank to check that acid is returning to the tank
16. Turn off acid cleaning pump by pressing the red "off" button on the acid cleaning pump control box
17. Turn off acid cleaning pump switch ***(located adjacent to acid cleaning pump)***
18. Close acid line valves V5, V12, V9 and V6
19. Slowly open valve V2 and then V1
20. Turn on wave pool chlorine boost pump on main pool ECB and wait for 5 minutes to allow acid to flush through the system
21. Turn on wave pool salt chlorinator on main pool ECB
22. Turn on wading pool chlorine boost pump on main pool ECB
23. Turn on wading pool salt chlorinator on main pool ECB
24. Turn on power to cells on wave pool chlorinator control board
25. Turn on power to cells on wading pool chlorinator control board
26. Log Acid Cell Cleaning onto your Daily Log Sheet

Note:
Wave Pool cells have now been acid washed. Both Wave Pool Salt Chlorinator and Wading Pool Salt Chlorinator are back on line

7.11 Preparation of Water Balance Chemicals

As further detailed in Section 9:-

8Kgs of Sodium Bicarbonate for every 100m3 of pool water will raise the TA by 50ppm
1.5Kgs of Calcium Chloride for every 100m3 of pool water will raise hardness by 10ppm

7.12 OPERATOR DUTIES

The following checks should be carried out daily apart from the normal water chemistry tests carried out through the day. This is a condensed version of Operators Duties. A more detailed explanation can be found in section 2.3.6 of the operating manual.

Apart from filter backwashing and some aspects in maintaining the water treatment plant the following requirements form part of the normal day to day requirements:-

(a) Vacuum clean pools
(b) Testing of Pool Water as per Northern Territory Health Department regulations
(c) Check water temperature and adjust temperature controls as deemed necessary
(d) Check display of Indicator Lights on all Control Boards
(e) Check contents of all Solution Containers
(f) Monitor all vacuum and pressure gauge readings
(g) Monitor Cl2 and pH readouts and compare to physical testing
(h) Check stock of chemical supply
(i) Check strainer baskets by gauge readings
(j) Conduct a visual and audible check of all items of plant and equipment
(k) When doing a filter backwash check the effectiveness of the pump-out system
(l) Check and clean gutter screens, as required.

8.0 MAINTENANCE & SERVICE & WARRANTY

8.1 General Considerations & Definitions

No pool complex will operate reliably unless all items of equipment are adequately maintained. Maintenance is commonly defined as the work and repairs that are necessary to maintain individual items of plant in a suitable working condition consistent with their expected service life.

Fundamental maintenance requirements are as follows:-

(a) Keep all work areas in a neat and orderly fashion.
(b) Follow a systematic plan for the execution of the daily operations that are outlined within this Manual. Routinely maintain the plant and its finishes.
(c) Establish a routine schedule, whereby individual work areas or plant rooms are vigorously inspected. If problems are discovered make timely decisions.
(d) Maintain meaningful records on all major items of plant. Apart from logging any repairs, record any unusual incidents or faulty operating conditions.
(e) Observe all common sense safety measures - do not tamper with equipment unless suitably trained & qualified.
(f) At the end of each month review all log sheets and test results and compile a summary of events.

Whilst Trisley's are responsible for the correction of defects that become apparent during the first twelve months of operation, the Pool Operator is required to operate and maintain the plant in a safe and efficient condition. Apart from maintaining accurate records, it is important for the Operator to appreciate that:-

(a) The plant must be operated in strict accordance with the instructions and or recommendations given on start-up and or detailed within this Manual. Warranty and or free service does allow for mis-use, abuse, water damage, negligence, and or accident. The golden rule is "IF IN DOUBT ASK"

(b) All pool water must be maintained and balanced in accordance with the Langelier Saturation Index whereby chemical concentrations are as recommended by the NT Health Department.

If a defect becomes apparent in the first twelve months of operation, its significance could vary quite substantially. Be this as it may, Trisley's must be advised of the potential problem when it first becomes apparent.

8.2 The Concept of Preventative Maintenance

For a facility to operate successfully on a year round basis, most Operators prefer to adopt a program of preventative maintenance. Under this arrangement any part or item that starts to show signs of wear is automatically repaired or replaced. This work is normally undertaken during a yearly close down period but with proper planning it can often be done, periodically throughout the year at times that are covenant to the Operator.

Rather than respond to random breakdowns, preventative maintenance is undertaken prior to the product's failure. Items that cannot be readily inspected (eg.., pump bearings, mechanical seals etc.,) should be replaced after a nominated number of running hours irrespective of their condition.

To manage an effective maintenance program, it is essential that all repairs and or replacements be accurately logged so that over time, the service life of the component or product can be established under actual operating conditions. With an accurate and meaningful service history parts (or items of plant) can be confidently reconditioned, repaired, or replaced at times that are convenient to the Operator. Refer to **Section 8.11** for a sample maintenance log sheet.

Whilst the Pool Operator may have the staff and the skill to undertake some routine maintenance, it is strongly recommended that after the twelve months defects period, service and maintenance arrangements is established for the more specialised items of plant.

8.3 Spare Parts & Consumables

Some spare parts and consumables should be maintained on site. Given that the Centre is new, the Operator will need to build up a stock of consumables and spare parts according to historic use .

8.4 Simple Do’s and Dont’s List

8.4.1 Don’t do this:-

Don’t operate a pump without first understanding its intended function.
Don’t operate any item of plant without first reading the manufacturer's instructions
Don’t run a pump without checking that all suction valves are fully open.
Don’t use valves on the suction side of the pump for flow throttling.
Don’t start a pump without first checking that there is an adequate water supply.
Don’t run a pump longer than one minute with the pump discharge valve fully closed
Don’t change any equipment settings indiscriminately
Don’t let untrained staff operate the plant and equipment
Don’t use flocculants (PAC) on the UFF filters.
Don’t wash the pool surrounds into the pool gutters.

8.4.2 These things must be done;

Please read these Instructions & feel free to ask questions and get more details
Do backwash filters according to an established timetable and log all details
Check all gauge and flow readings on a DAILY basis.
Get the pool water biologically tested every three months.
Use Log Sheets to manage day to day activities & record meaningful information.
Regularly check the performance of the backwash pump out system
Use a face mask when handling dry powder filter aids
Check and monitor the progressive build-up of TDS
Ensure adequate stocks of chemicals and consumables are on hand.
No matter how small the apparent problem, feel free to talk to Trisley's

8.5 Common Maintenance Problems

8.5.1 Introduction

Although the maintenance requirements for commercially available items such as pumps, valves, flow switches, etc., are provided in Part B of this manual, the following notes are intended to assist the pool Operator with some common maintenance issues. This information should be read in conjunction with all other information provided by Trisley Hydraulic Services.

8.5.2 Precoat Filtration

With regard to the maintenance of the UFF filters it is important to understand that this form of filtration has a very fine particle selectivity. When first filling a pool it is important that all construction work around the pool has been fully completed and that any construction debris has been removed from the pool system (ie.., pool gutters, balance tanks, etc.,). Initially the pool should be overfilled and superchlorinated. The pool should be allowed to settled for up to 48 hours then vacuumed cleaned to waste.

When first starting a precoat (UFF) plant monitor the pressure gauges carefully. Given the particle selectivity of precoat filtration, it is not uncommon that frequent backwashing may be initially required.

At least once a year, it is required to lift the filter head and conduct a manual clean-out of the filter vessel. During this time, the cloth covered candles should be inspected. Under high organic loads, the cloth covered filter candles may become clogged and require an acid wash. Grease and body oils can also be removed by washing the cloth filter bags in a strong detergent. The service life of the cloth filter bags will vary from one to three years depending upon conditions. Filter bags should be periodically replaced on a need basis. This type of service work should be undertaken by an approved and authorised service Agent.

It is important to note that failure to use new filter media after each and very filter cycle will cause major binding problems that will necessitate the supply of new filter bags that are not covered by warranty. The prescribed amount of filter media must be added after each and every backwash.

PAC IS NOT TO BE USED UNDER ANY CIRCUMSTANCES. The use of PAC in conjunction with precoat filters will cause significant damage to the internal elements. As well as voiding the filter’s warranty, the ability of the filters to maintain water clarity will be diminished.

Daily Requirements:
Filter pressures to be logged. Backwashing carried out as per procedure manuals.

Yearly Requirements:
After the filters have been in service for 9,000 hours a major service on the internal filter elements should be carried out by an Authorised Agent. This will require the following;

- Removal of filter elements and acid cleaning of the cloth fabric. This removes the build up of calcium deposits that accumulates over a period of time.
- Visual examination of cloth covered filter candles & O Ring seals
- Visual examination of coated tube/pressure plates
- Maintenance on ancillary plant including lubrication of valve gearbox, tank mixer service, visual inspection and clean out of solids separation tank, spa bag filter,

8.5.3 Chemical Dosing

In their concentrated form most pool chemicals are corrosive and caustic. Most chemicals will attack metals and in time they will affect rubber and elastomeric parts. A planned replacement of seals, check valves, and diaphragms will ensure long term trouble free performance. Checkvalves on positive displacement pumps are important. Whilst they must close tightly to produce accurate output; they also must close to prevent siphoning when the pump is switched off.

Make sure that suction screens are in place and that they remain clean. If a positive displacement pump fails to pump even though the motor is running, the first thing to inspect is dirty valves. Whilst maintenance intervals should be dictated by the actual operating conditions, the Manufacturer recommends that:-

- the Dosing Diaphragm, valves, o rings, valve ball, and valve seat be replaced either after 2000 hours of operation or annually. Note these replacement parts should be considered to be consumables.
- the Gear Head be greased after a maximum of 8,000 operating hours or in continuous operation, after one year.

Daily
- Physical check that chemical levels are correct, pumps are working with no leaks. General visual check that the chemical system is working and that there are no leaks either from the pumps, feed lines or from the day tanks or bulk tanks.

Weekly
- Calibration checks on the probes should be carried out every week. This will need to be done by an authorised Prominent service agent if there are no pool staff available with the necessary experience.

Monthly
- Probes require manual cleaning every month for pools. The Chlorine injector requires cleaning every month. To do this the filtration system need not be turned off. Turn off the chemical supply pump and remove the injector and wash off any chlorine. Then immerse the injector in a weak solution of acid and water (7:1). Once all the calcium buildup has been removed,

replace the injector. Check all dosing pump suction valves.

- The chlorine probes installed at the Centre are of the free chlorine type and have a membrane fitted. The membrane is protected by a gel substance, which dissipates with time. This gel needs to be replaced usually every 6 months. Failure to do this can lead to failure of the entire probe which is an expensive piece of equipment. We recommend that the gel be topped up every 6 months to avoid costly probe replacements.

Three Monthly
- A microbiological test should be carried out every three months.

Yearly
- Dosing pumps should be stripped down yearly and checked with a view to replacing the diaphragm and wet end parts.

Salt Chlorinators
The units installed are relatively maintenance free except for the acid cleaning of the salt cells. The operator will need to refer to the manufacturers manual for more detailed instructions on maintenance / service intervals.

Dry Chlorine Feeders
The units installed are relatively maintenance free as they are self cleaning units. The operator will need to refer to the manufacturers manual for more detailed instructions on maintenance / service intervals.

8.5.4 Pumps & Motors, Generally

Although detailed maintenance instructions are provided within other Volumes of this manual, the following Manufacturers recommendations for key items of plant should be noted.

Bearings with lubrication points should be greased every 1000 to 2000 operating hours depending on the severity of service. For pumps operating continuously 24 hours per day this would be every 6 to 12 weeks. For pumps operating eight hours per day for five days, this would be every 6 to 12 months. For pumps used infrequently the bearings should have grease added at 12 month intervals.

Daily
A “walk through” to check for leaks, abnormal noise and operating pressures. Any problems should be logged and then attended to by maintenance staff.

Yearly
All pumps should be inspected yearly for wear to mechanical seals, erosion of back plates and impeller wear. A program of seal replacement should be carried out after the pumps have been in service for 15,000 hours.

8.6 FAULT FINDING

High vacuum gauge reading	Suction valve inadvertently restricted, pre-pump strainer is dirty.
Pump won't start	Probable cause will be electrical
	Check for burnt windings in pump, Pump won't work if insufficient flow. Check flow switch for broken paddle or loose connection. Also check for electrical overloads in control board.
Incorrect probe readings	Probes either dirty or out of calibration
	Remove probes and clean as per manual. If clean check calibration. Probe may be at end of life (2 years approx), replace if necessary. Check water balance.
Chemical pumps not pumping	Probable cause is flow
	Check that there are no air locks in suction line. Check for blocked injector points. Check for broken pump diaphragm.
Water is cloudy	Probable cause is chemical.
	Check water balance and adjust as necessary. Check that plant is fully operational. Bather load to be reduced until water clarity returns. Check that the system may need a backwash or check the backwash procedure.
D.E Filter powder in pool	Break or tear in filter element
	The filter should be isolated and the broken element cloth replaced.
Pool Water Milky	Could be dissolved gases in solution. Could be heavily aerated water. Could be filter media leaching back to pool.

8.7 Warranty

All items of mechanical equipment employed on this project are subject to Manufacturers warranty which is conditional upon:-

- Adherence to all operating requirements,
- that "fair wear and tear" be accepted, and,
- that a set claim procedure be followed.

Notwithstanding, Trisley's Hydraulics Services warrants the plant installation (limited by his scope of works) for a period of twelve months from the date of practical completion. Refer to Part B for specific warranty terms and conditions

8.8 Service Contact Details

Trisley's Hydraulic Services may be contacted during normal business hours by phone,

PHONE 02 8566 3666.

Out of hours messages may be lodged by

Fax on 02 8566 3667

or email to **service@trisley.com.au**

Emergency out of hours messages can be directed to:-

Greg Flood	**(0418) 443 143**
Stuart Crane	**(0408) 292 272**

Trisley's Hydraulic Services has an agreement in place with a local contractor who in our absence will undertake any warranty work if required. However, all requests for post contract support must initially be directed to THS.

Attendance to issues other than those required by Contract will attract a service charge at the current commercial rates.

8.9 Summary of Equipment Suppliers

UFF Filters	Atlas Australia Pty Ltd.
Filter Valves are by SH	Trisley's Hydraulic Services.
Strainers	Fulham Fabrications Pty Ltd.
Main Re-circulating Pumps	Total Pump Solutions Pty Ltd
Chemical Controllers	Prominent Pty Ltd
Dosing Pumps	Prominent Pty Ltd.
Salt Chlorinators	Prominent Pty Ltd
Dry Chlorine Feeders	International Quadratics Pty Ltd
Pressure Gauges	Burkett Pty Ltd.
Binder Gauge Connections	Binder Engineering Pty Ltd.
Chemical Dosing Tubing	Prominent.
Electrical Control Board	CVP Electrical Pty Ltd
Flow Switches	Kelco Engineering Pty Ltd
Bulk Air Releases	Amiad Pty Ltd
Air Blowers	Esam Pty Ltd
Wet Deck Grating	Hydrocare Pty Ltd
Wave Machine	Murphy Waves Pty Ltd

8.10 Maintenance Records

The foundation of any good maintenance system is an equipment record system that makes all necessary equipment maintenance information readily accessible to maintenance personnel. The equipment record system should ensure that various sources of information are brought together, consolidated, and cross referenced, so that personnel can easily find information on proper procedures, and can schedule necessary maintenance.

Regardless of who undertakes any service and or maintenance work, the Pool Operator is totally responsible for maintaining proper maintenance records. Refer to the sample Maintenance Log Sheet in **Section 8.11** for the minimum requirements that apply to all major items of plant.

8.11 Example of a Typical Plant Maintenance Log:

DARWIN CITY WATERFRONT POOL EQUIPMENT MAINTENANCE LOG

Equipment Code :

Product Description :

Manufacturer Details :

Serial Number : Model Number :

Rated Conditions :

Construction Materials :

Special Notes:

DETAILS OF INSPECTION & REPAIRS

Date	Work Undertaken	Done By	Remarks	Cost
……..				
……..				
……..				
……..				
……..				
……..				
……..				

8.12 Example of a water chemistry log sheet

Date	Time	Digital	Act	Digital	Act	Total	C/Hard	Temp	Sat	Chemicals	Comments	
		Cl2	Cl2	pH	pH	Alk			Index	Added		

The above information will provide the operator with sufficient information to ensure that the pools' water chemistry parameters are in line with safe bathing requirements.

9 WATER TREATMENT & POOL CHEMISTRY

9.1 Introduction

It is essential for the Operator to know what quality of water is needed and why it is important. Swimming pool water should be free of bacteria (particularly the disease producing kinds), turbidity, algae, and colour and be low in scale forming chemicals.
Because bacteria is introduced into the pool water from many different sources, it is necessary to maintain constant vigilance to keep them under control.

Whilst turbidity will result in visually unpleasant water quality, it should be also accepted that highly turbid water is dangerous - a bather in trouble must be seen to be rescued. Bacteria may develop in sufficient amounts to cause cloudiness. These growths may result from heavy bathing loads and poor disinfectant practices.

Algae is controlled by the same disinfectants and or processes that are used to maintain the water free of bacteria. Colour may develop from one or more causes. Minerals such as iron, manganese and copper are frequently present in very low concentrations. Manganese may not be noticed until extra chlorine is added or until it is necessary to raise the pH.

Copper is relatively colourless until or unless ammonia is present. Urine contributes ammonia such that copper can frequently impart a light blue or green cast to the water. Iron is less common, but is present in some mains water supplies. Whilst minerals are not necessarily dangerous; the resultant colour can be objectionable.

Scale may make a beautiful pool so rough that it is dangerous to brush against the sides of the pool. The scale may be calcium carbonate (which precipitates from the pool water) or it may be silica which forms much more slowly. The same chemicals which, can form scale may precipitate in the water to make it cloudy; this can be common when a pool is filled with "hard" water.

In summary swimming pool water should be pleasing to the eyes of the onlookers and bathers. It should also be safe for the swimmer in being free from disease bacteria and irritating chemicals.

9.2 Disinfection

Without proper management swimming pools can be breading places for most of the water-borne infection and disease-producing organisms known to man. Modern swimming pools are less apt to contain many of these organisms which were transmitted by people years ago in less enlightened times. Sanitarians generally agree that bacterial standards set for pools must be observed in order to minimise cross infection. This is particularly important as modern pools are characterised by increasingly heavier bathing loads and higher operating temperatures. Some of the essential criteria for a good disinfecting agent are as follows:-

(a) that it have a measurable residual;
(b) that it be easy to apply; and,

(c) be readily available at a reasonable cost.

Other desirable characteristics are that it be compatible with other pool chemicals used; that it not impart an unpleasantnesses to the water; and that it not be detrimental to the bather's health in the normal use situation. In the main the swimming pool Industry has settled on the use of relatively few chemicals for this purpose. It is not particularly surprising that these chemicals are members of the halogen family when one considers the fact that chlorine and chlorine bearing compounds were the original materials used for general water treatment.

9.3 Water Chlorination

Chlorination of water can be achieved through the use of elemental chlorine, calcium, lithium or sodium hypochlorite, and or chlorinated isocyanurates. In each instance, disinfection is obtained through the formation of hypochlorous acid, a reaction product of any of the above chlorine forms and water.

Hypochlorous acid (HOCl) dissociates to the hypochlorite form (OCl-) according to the pH of the water. This relationship between pH and the form of chlorine exists in when dissolved in water can be seen in the following table:-

Table: Chlorine Efficiency at Different pH Levels

pH Level	% of Chlorine as OCI	% of Chlorine as HOCI
6.0	3.5 %	96.5 %
6.5	10 %	90 %
7.0	27.5 %	72.5 %
7.5	50 %	50 %
8.0	78.5 %	21.5 %
8.5	90 %	10 %

Since the HOCl form is considerably more effective than OCI (for killing bacteria and other microorganisms) the importance for proper pH control can be understood. For example, at a high pH the chlorine present in pool water is less active as a disinfecting agent.
Ammonia and other nitrogen containing compounds when present in pool water will react with chlorine to form chloramines. Chlorine in the combined or chloramine form is considerably less active in killing bacteria than the free or uncombined form.

Notwithstanding, it should be noted that chloramines or the combined form of chlorine will give a positive test when using a standard pool water test kit. To provide the desired free residual in a conventional chlorine pool and to avoid chlorine odours and eye irritation (from the presence of chloramines) superchlorination of the pool should be done at least weekly. Superchlorination, which consists of raising the chlorine residual to 5 to even 10 ppm, will also allow control of algae which may develop at normal chlorine residual levels. Whilst the need to superchlorinate a well managed pool is comparatively rare, bathers should not be allowed to use the pool if and when it is

necessary to raise chlorine levels above normal readings.

If it were necessary to de-chlorinate a conventional hypo pool, sodium thiosulphate (photographic hypo) would be used at the rate of 1 Kg per 50 m3 of pool water. Chlorine demand, or the amount of chlorine required, for any particular pool or spa cannot be predicted and must be determined by frequent tests of the water.

To reduce the extent of such manual testing, water chemistry controllers are provided to measure and proportional dose according to set point need. Chlorine is consumed when destroying bacteria and other organisms and when reacting with metal salts such as iron and manganese, if present. Sunlight, water temperature, bather load, and numerous contaminates carried into the pool water will effect the chlorine demand.

The residual sanitiser at Darwin City Waterfront is via electrolytic salt chlorinators. The electrolysis process generates Hypochlorous Acid which is injected into the pool on a needs basis.

9.4 Dry Chlorine

The plant has installed a dry feed chlorine backup system. Calcium Hypochlorite is stored in a hopper in the plantroom. Once signalled that Chlorine is required, a worm gear drops a specified amount of chlorine into the hopper. The venturi system then injects this into the water on a needs basis.

Calcium Hypochlorite (frequently referred to as dry chlorine) is commonly used as a chlorine source for treating swimming pools. The chemical is sold in granular form with an available chlorine concentration of approximately 65 %.

For every 100 m3 pool capacity, 0.3 kg of Calcium Hypochlorite would be required to introduce one milligram per litre. Chlorine tends to be decomposed by sunlight, heat and some metal contaminants. The decomposition rate or loss of strength rate is many times faster than for the dry chlorine chemicals. Therefore, it is necessary to keep it stored in its original plastic container in a cool place.

The same free alkali that forms the basis of calcium based chlorines tends to drive up pH of the water in the pool when it is introduced. This can necessitate the need for an increased acid (or Carbon Dioxide) requirement to maintain a balanced water with acceptable total alkalinity and in proper pH range. When Calcium Hypochlorite is diluted prior to use with hard water, or when it is introduced through feeding equipment into hard water, calcium deposits and precipitates may form. This necessitates the need to periodically pump a dilute solution of Muriatic acid through the equipment to remove the deposits. Calcium Hypochlorite solution is introduced to the pools via chemical solution venturi pumps that are controlled by Water Chemistry Controllers - see **Section 6.3** for details. Care should be taken not to spill Calcium Hypochlorite on pool fixtures, equipment or clothing, since it is corrosive and a strong bleach. Spills should be flushed immediately with large quantities of water.

9.5 Basic Water Chemistry

Here we are concerned with the need to keep the water balanced chemically with respect to pH, total alkalinity, water hardness, and to some extent, the total solids.
A chemical balance in the pool water is needed:

(a) To increase the effectiveness of the disinfectant used
(b) To prevent scale formation, blocking of the filter and cloudy water.
(c) To prevent at the other extreme, corrosion of plaster and metal fixtures and or extreme eye irritation.

9.6 pH versus Total Alkalinity

First we should differentiate between the pH and total alkalinity. The term pH can be defined technically as the negative log of the hydrogen ion concentration and is often referred to as just the hydrogen ion concentration of the water. Generally in the pool Industry, we speak of pH as relative acidity or relative alkalinity balance at a particular time. It is a term of relative intensity, expressed on a numerical scale of 0 to 14 as illustrated below.

Table : pH Scale

Strongly Acid						Neutral							Strongly Alkaline	
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Muriatic Acid has a pH of about 0. Pure water is 7 (neutral). Weak Lye solutions have a pH of about 13 - 14.

REMEMBER; *Chemicals that are acid..... lower pH.*
Chemicals that are alkaline..... raise pH.

In the treatment of swimming pool waters we normally are concerned with the pH range of 6.8 to 8.4 as generally illustrated below.

Table: Common pH Range

6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4
Add soda ash or sodium bicarbonate	Marginal		Ideal		Marginal		Add acid	

The pH changes abruptly or gradually, it may go up or down from time to time, depending not just upon what chemicals are added to the water but to a very great extent it is dependant upon the total alkalinity of the water. Now the total alkalinity on the other hand, is the total amount of certain alkaline chemicals in the water. These alkaline chemicals continue to affect the stability and changes in pH. The total alkalinity of the water, more or less holds the strings that regulate pH. We

could use an analogy here of a flashlight battery. The voltage of a car battery can be compared with pH and the capacity of the battery compared to the total alkalinity. For example, a certain voltage is required to light up a flashlight bulb, but just how long it will keep will depend on the capacity of the battery.

Total alkalinity tells you how much; pH more or less tells you the degree or intensity at a particular time. At normal swimming pool pH levels, the total alkalinity is usually a measure of the amount of bicarbonates in the water. At high pH you would have some carbonates such as soda ash and hydroxides (such as lye) that may be measured as part of the total alkalinity. However, once the pH is adjusted to below 8.4, these two will no longer be present. Usually a pH of 7.4 - 7.6 is recommended for pool water in order to increase the effectiveness of the chlorine residual present.

At low pH a greater percentage of the chlorine residual will be in the form of the considerably more active hypochlorous acid form and less in the less active hypochlorite ion form. In order to maintain pH effectively in the 7.4 - 7.6 range, it has been found that total alkalinity should be balanced in the range of 80 - 100 ppm. This is a good preventative maintenance.

With ideal initial water balance you will be able to resist sudden undesirable changes in the condition of the water due to influences such as the addition of chemicals, addition of make-up water etc. It is highly desirable to adjust the total alkalinity of the water to the 80 - 100 ppm range as soon as possible.

NOTE : THE FOLLOWING SECTIONS 9.7, 9.8, 9.9 DISCUSS WATER PARAMETERS FOR PH AND ALKALINITY LEVELS. ON COMMISSIONING, MAINS WATER TESTED AT THE DARWIN CITY WATERFRONT WAS FOUND TO BE GENERALLY STABLE WITH A PH LEVEL OF 7.5 AND AN ALKALINITY LEVEL OF 80PPM.

9.7 Low Total Alkalinity

In many areas of the country the total alkalinity of the water source is quite low. You might say that the pH is more or less under-stabilized. In this type of area:

(a) The pH changes abruptly and frequently with small additions of chemicals.
(b) The water tends to be more corrosive to plaster and metal fittings with this low total alkalinity. This often results in stains on the plaster or rough finish to the plaster.
(c) Low total alkalinity often results in low pH and eye irritation.
(d) Often there is difficulty with the use of an alum floc for sand and gravel filters.

If the total alkalinity is low, it can be adjusted merely by the addition of sodium bicarbonate to the water. This adjustment with sodium bicarbonate can be done at least once, since this is a mild type of chemical.

To raise total alkalinity by 50 ppm, add 9 Kgs of sodium bicarbonate for every 100 m3 of water volume. Whilst soda ash (sodium carbonate) also will also increase the alkalinity to some extent, it tends to increase the pH too much to be practical. It should be remembered that when you want to

raise the pH and not the total alkalinity use soda ash, but when you need to adjust total alkalinity use sodium bicarbonate.

9.8 High pH, Low Total Alkalinity Water

In still other areas around the Country, we find water with a high pH, but a low total alkalinity. Sometimes in such areas pH is greater than 9 - perhaps a high as 10.
When acid is added to this water to adjust the pH, it is found that often the pH will drop abruptly to below 7, even with only small additions of acid. As a result, plaster may be etched and or the metal fixtures in the system may be corroded.

These dissolved metals eventually stain the pool - green, blue or gray to almost black copper stains or yellowish brown to brown iron stains. The way to avoid this problem would be very simply to first test for total alkalinity and adjust it to the desirable 80 to 100 ppm range with sodium bicarbonate. Then, acid can be added to adjust the pH to the proper range. You will actually find that when the sodium bicarbonate is added to this high pH water there actually will be some decrease in pH since the sodium bicarbonate has a pH lower than that of fresh water.

9.9 High Total Alkalinity Water

In still other areas of the country we find that there is an excessive total alkalinity in the water. A high level as high as 300 - 400 ppm may be found. In such cases the pH may be considered to be over-stabilized so that it tends to remain at a level around 8.4. When acid is added to this type of water to drop the pH to 7.4 we find that after a very short period of time the pH will bounce back up to about 8.2- 8.4. This process must be repeated many times in order to eventually "stabilize" the pH at the more desirable range of approximately 8.4.

What happens is that every time acid is added, a small amount of the total alkalinity is destroyed or neutralized, carbon dioxide gas is formed, and in the process the pH is lowered to the 7.4 range. However, since there is still an excessive total alkalinity remaining, the pH will bounce back up to approximately 8.4. After a period of time when enough of the excess alkalinity has been destroyed to reduce the level to around 100 ppm, it is found that the pH does not bounce up nearly as rapidly or as high as it did when there was a large excess of total alkalinity present.

Also less acid will be required for each pH adjustment. That is, it takes less acid to go from, say, a pH of 8.0 to a pH of 7.4 as the total alkalinity is reduced.

It should be pointed out that even in areas of high total alkalinity you often have tap water with a pH of 7.2 - 7.4. This is of course, due to the fact that the supply water was treated and delivered from a treatment plant. When such water is added to the swimming pool, the pH of the water will very shortly rise to the 8.4 level (since the high carbon dioxide level of the water is lost to the air rather quickly) and since the total alkalinity is high, it will take many additions of acid before the pH will tend to remain at the 7.4 - 7.6 level.

Test for T.A. should be run approximately once a week until the proper range of 80 -100 ppm has been achieved. Then tests are run approximately once a month in order to determine if the desired

range is being maintained. It should be remembered the total alkalinity does not change abruptly as does pH but rather it will gradually, over a period of time, tend to rise due to the addition of refill water with a high total alkalinity count and decrease due to the additions of refill water with a low total alkalinity count.

There are a number of areas in the country where water systems with low total alkalinity are located very close to water systems with high total alkalinity. In these areas the swimming pool operators, pool service men and dealers can run into many problems unless they understand total alkalinity and test for it regularly. For example, in the area with the high total alkalinity it may take a ten litres of acid to drop the ph of the pool water from 8.0 to approximately the 7.4 - 7.6 range.

If total alkalinity is low, however, a litre of acid may be all that is needed to get the same effect. If more than this litre of acid is added the pH often will be dropped to the acid side and as a result there is corrosion of the metal pipes and the fixtures in the pool, etching of the plaster and the danger of eye irritation of the swimmers. These problems can be avoided very simply by testing the pool water for total alkalinity and adjusting to a desired range.

The total alkalinity test also is a very valuable tool for trouble shooting and solving of existing swimming pool problems. For example, if you analyse pool water for just pH it is often difficult to diagnose a pool problem, since the pH changes frequently and at the time you run the test is usually different from what it was at the time the problem was caused.

Total alkalinity, on the other hand, changes only gradually so that comparing the total alkalinity of the pool water with the total alkalinity of the pool water of an earlier pool water sample or a tap water sample you can often determine what happened to the pool since it was filled or last checked.

You can determine, for example, if excessive amounts of acid have been used in the pool to lower the total alkalinity to an undesirable low level. You also can determine if insufficient acid has been used to maintain proper pH, so that total alkalinity has either gone up with time or has not been reduced from what was initially an undesirable high level.

Some Pool Operators run into difficulty because they do not realise that although relatively large amounts of acid are needed fairly frequently with a pool that has been recently filled with high total alkalinity water, that after a period of time - as the alkalinity has been reduced less acid is needed with each adjustment and acid is needed less often. Such Operators fail to gradually reduce the amount and frequency of acid additions so that low pH, corrosion and eye irritation result.

9.10 Water Hardness

Water hardness is another property of swimming pool water that should be taken into consideration. Water hardness is the measure chiefly of the calcium and magnesium in the water. It tells how much there is present. Although the magnesium is of less concern, the calcium content of the water is very important, because it is the calcium content that combines with some of the total alkalinity to form scale.

You should never soften pool water to zero calcium hardness because then the water will be more corrosive to the plaster finish of a pool and to the metal pipes and fixtures. A water which has a high hardness content should be softened to approximately five grains minimum. If the water hardness is too low a chemical such as calcium chloride can be added to increase the hardness level. It should be kept in mind that this chemical is weakly acid and will tend to lower pH.

To increase calcium hardness by 10 ppm, add 15 grams of Calcium Chloride per 1m3 of pool water.

The test for total hardness is very simple and only takes a few minutes to run. Most test kits use a dye that changes color. Please follow the directions on your test kit as tests differ depending upon the test kit manufacturer.

In some cases you will find that the dye will change to a blue, go back to purple and then go back to blue as you add more drops of the test solution. This is an indication that there are certain metals ion in the pool which are interfering with the test. If this happens the test will not be valid unless you add a certain chemical called an inhibitor. Another caution which should be pointed out is the fact that occasionally some of the chemical solutions which are used will crystalize or settle out to some degree. If this happens the solutions should be discarded and fresh solution purchased. Otherwise, results may be considerably in error and have no value.

The test for total hardness measures both calcium and magnesium. Since only the calcium level in the water is really to concern the value for total hardness is usually multiplied by a factor such as 0.7 to give an average value for calcium in the water.
Since the calcium content of the water usually increases slowly due to evaporation of pool water and subsequent additions of raw water, the tests for total hardness usually run only about once or twice a year.

9.11 Water Balance Index

By knowing the calcium content of the water, the total alkalinity, pH and temperature of the water you can readily determine an overall water balance called the Langlier index. This Langlier index is an equation which totals up factors such as calcium hardness, total alkalinity, pH and temperature and only to a minor extent the total solids present in the water. This will tell you if the water is going to be corrosive to the tiles and grout of the pool or whether the water is saturated in respect to calcium and will deposit a calcium scale either on the tiles, in the filter or in the coils of the heater.

9.12 The Enigma of Total Dissolved Solids

Have you ever worked with a pool that just didn’t seem to respond to any treatment? One day the chlorine residual was high, the next day it was low without any apparent reason. Have you ever had a good free available chlorine residual but found that algae was growing and slime or mould had started to grow? Did you ever add large quantities of acid or soda ash without affecting a substantial change in pH?

Or how about coloured or murky water, when the filter was operating perfectly and superchlorination was regularly practised? How did you handle that one? Did you find scale in a pool, although everything was in its proper range and Langlier's formulae said it was in good balance? Or how about peculiar colours and stains forming on the surfaces of the pool? Eyes burn, but free chlorine and pH were right?

During this time you used the best test kits available and you replaced all the old reagents with fresh material. You tested for everything you could think of and bought every conceivable wonder cure that you could think of. Still, the problems persisted.

Then you checked the stabiliser level. Good heavens....it's 105 ppm or maybe even 200ppm of cyanuric acid and then you say, "now I've found the problem". So you drain the pool, or at least remove part of the water and surprise, surprise, all the problems magically disappeared. Cyanuric acid, you conclude is the culprit - the source of all your problems. The pool is "overstabilzed" because the algae and bacteria are growing, there's no more free chlorine, the pH is erratic, your pool ladder is rusting, and the tiles are falling off the wall. But, and this is a big "but", if the cyanuric level has increased in the pool, so too has the total dissolved solids. Although total dissolved solids is not a new concept, it is rarely managed and controlled in a professional manner.

Anyway, where does TDS come from? The mains water that is used to fill the pool, usually contains hardness such as calcium and alkalinity-like carbonates, as well as dissolved organic and inorganic materials such as sulphate or silicate. In addition the salts from the residual of active chlorine that has been used up to form chloride, swimmer sweat, urine waste, unsuperchlorinated solids such as creatine, soluble hair sprays and body lotions add to the total. Wait! There is still more, in an outdoor pool, the wind blows in leaves and grass clippings, as well as material contained in rain that has passed through polluted air. Once in the pool, all this stuff becomes more and more concentrated.

These solids can be further increased by the effects of evaporation. This could double or even triple the solids content with the pool in a single year.

Filter backwashing is often the only "management" tool that is ever used to control the build-up of a pool's total dissolved solids. But new technology and the ever increasing cost of raw water has resulted in the development of modern filters (both sand and media type) that provide longer filter cycles and have shorter backwash times. Such plants do not necessarily consume enough pool wash water to effectively control TDS.

Some European standards legislated that 30 litres of pool water be dumped for every bather that uses the pool. Whilst this may have the desired effect, it does not provide a very scientific or logical approach that can be sensibly managed and controlled by the Pool Operator.

TDS should be prevented from accumulating within a pool by following a proper maintenance program that includes periodic disposal of some water from the pool. Rather than being based on myths, old wives tales and generic rules of thumb, such a program should be based on actual measured values, albeit TDS or more convenient conductivity. It is important to realise that pool make up water will have a TDS reading (albeit substantially lower than what can found in most

swimming pools) and that proper controls are fundamental required. You wouldn't necessarily add chlorine according to the number of bathers in the pool. You would naturally test the water for free chlorine and add an appropriate dose. So to for TDS. It should be measured and controlled, before blindly dumping valuable pool water.

What possible benefits can be obtained by monitoring and controlling TDS. We already have enough things to worry about without adding yet another constraint! The answers simple; from a disaffection point of view, the steriliser that you are currently using will be infinitely more effective if the TDS readings are properly managed. In simple terms, imagine that you are at one end of a pool and you are trying to reach the other end. Nothing is in the water but you.

Pretty simple, isn't it? Now some other swimmers are added, which obviously get in your way. The greater the number of swimmers the more difficult it will be for you to get to the other end. Imagine that you are a chlorine molecule and the spot on the other end of the pool is bacteria; and the swimmers are dissolved solids. This may help to understand why a concentration of TDS can interfere with the bacteriocidal activity of chlorine; simply because of the crowding effect. Whilst this is a vast oversimplification, pool water chemistry can be quite complex and it is usually not, just a simple one on one relationships.

Given the ever increasing cost of incoming mains water and the outgoing cost (and all the regulations) that are associated with the discharge of pool water, numerous benefits can be obtained by monitoring and managing the progressive build-up of Total Dissolved Solids. Possibly the largest single benefit, is the potential for the beneficial re-use of wash water for irrigation purposes. Given that this re-use is entirely dependant upon the salinity of the waste water (and that it is subject to approval by the Environmental Protection Authority) the control of TDS can open up many opportunities. Without effective control of TDS, you can forget any chance of using pool water for irrigation.

9.13 General Notes and Comments

On no account must pool chemicals be mixed with each other in the dry state or in solution, except in the swimming pool itself. As mild as it may seem, Sodium or calcium Hypochlorite is an oxidizing compound and as such is incompatible with quaternary ammonia type algaecides any other organic substances such as wood, some packaging materials etc.,

Important Note:-

Disinfectants containing Phenols and or Ammonia should not be used at any stage to clean pool surrounds or fixtures.