SEWPCC Upgrading/Expansion
Conceptual Design Report

SECTION 17 - Electrical and Instrumentation

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17.0 Electrical and Instrumentation

17.1 INTRODUCTION

This section is the result of discussions with the City, meetings with Manitoba Hydro, and evaluation of the existing SEWPCC electrical, control, instrumentation and automation systems with the process and support requirements of the expanded and upgraded plant.

In this section, details are provided and recommendations made on each of the major Electrical and Instrumentation systems, identifying the proposed basis for proceeding with Detailed Design. Control System is discussed in Section 18.1 - Controls Platform and Automation.

17.2 MAIN POWER SERVICE

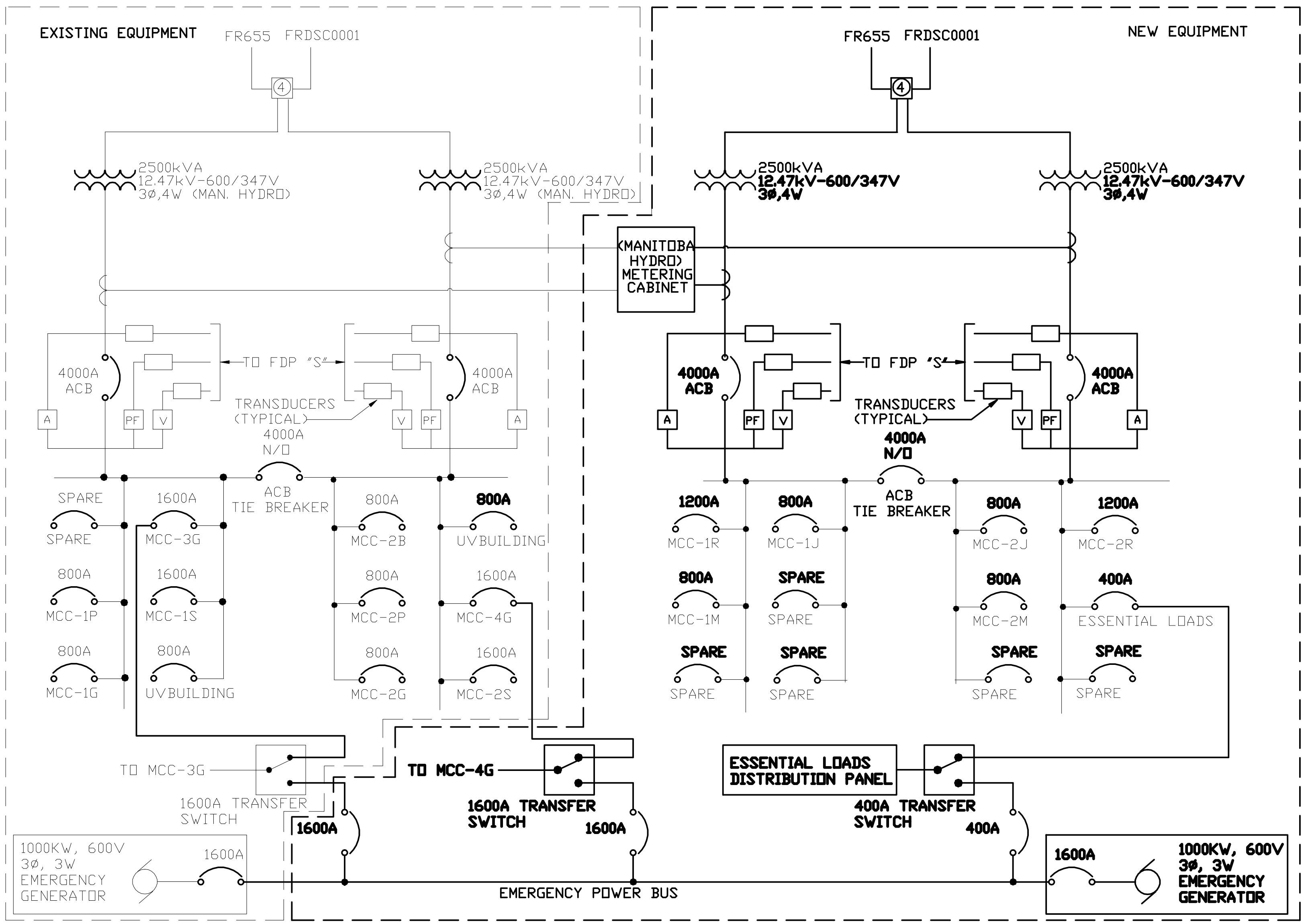
17.2.1 Main Feeders and Transformation

Manitoba Hydro has confirmed their plan to upgrade the Frobisher substation, which feeds the SEWPCC Plant and also the surrounding community, to provide additional capacity and reliability. Manitoba Hydro is upgrading the feed to the SEWPCC by providing a new underground cable from Frobisher substation to the location where the current overhead line goes underground at the property line. A new Disconnect Switch Center (DSC) isolation switch will be installed at that location and Stantec recommends that the existing overhead line, the new underground line, and the DSC be configured to provide two separate 12.47 kV feeders to the Plant. Refer to Figure 17.1 and Figure 17.2 showing proposed locations for the new transformers.

The two existing 2500 kVA transformers, which are presently owned and maintained by Manitoba Hydro, may be offered to the City for purchase, likely at nominal cost. Manitoba Hydro is in the process of preparing proposals for the City that Manitoba Hydro has indicated may be financially advantageous to the City. These proposals should address ownership of transformers and the option of primary metering. Stantec will assist the City in evaluation these proposals when they are received.

The existing transformers are believed to be approximately 35 to 40 years old and in discussion, Manitoba Hydro indicated that they do not have specific maintenance records for them. The age of the transformers alone is not regarded by the industry as reason to consider replacing them.

With the configuration of the Plant's electrical system, retaining the existing transformers offers cost savings both in labor and material for the expansion project and reduced complexity, reducing the requirement for interruption of plant systems during construction. The recommendation to retain these transformers is addressed further in Section 17.2.2.



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HOR. SCALE: VERTICAL:	N.T.S.	RELEASED FOR CONSTRUCTION:	
DATE	08.07.07	DATE	

ENGINEER'S SEAL

TENDER NO.

THE CITY OF WINNIPEG

WATER AND WASTE DEPARTMENT

Winnipeg

SOUTH END WATER POLLUTION CONTROL CENTRE

SINGLE LINE DIAGRAM

CITY DRAWING NUMBER: FIGURE 17.1

SHEET 1 OF 1

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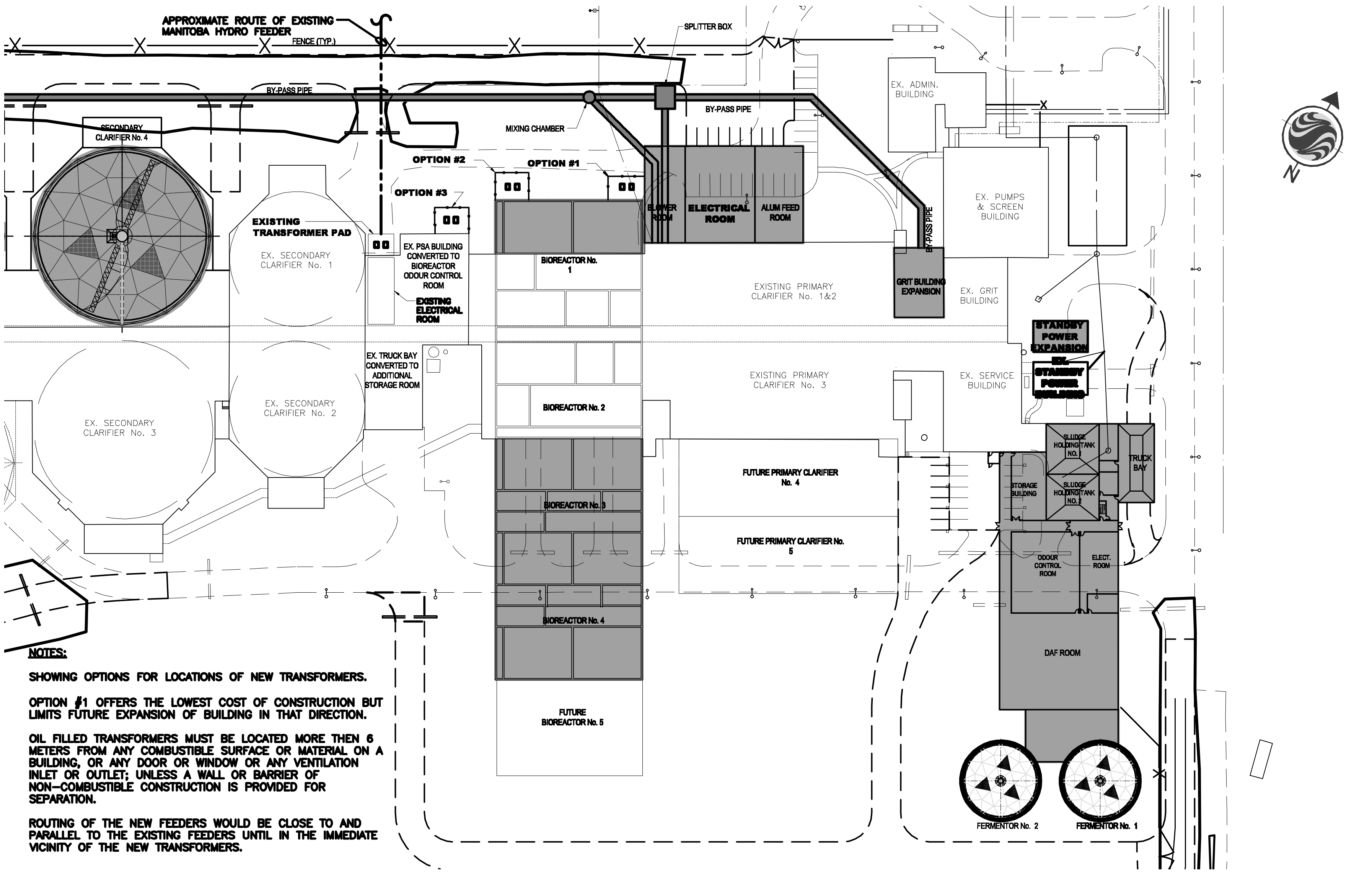

NOTES:

SHOWING OPTIONS FOR LOCATIONS OF NEW TRANSFORMERS.

OPTION #1 OFFERS THE LOWEST COST OF CONSTRUCTION BUT LIMITS FUTURE EXPANSION OF BUILDING IN THAT DIRECTION.

OIL FILLED TRANSFORMERS MUST BE LOCATED MORE THEN 6 METERS FROM ANY COMBUSTIBLE SURFACE OR MATERIAL ON A BUILDING, OR ANY DOOR OR WINDOW OR ANY VENTILATION INLET OR OUTLET; UNLESS A WALL OR BARRIER OF NON-COMBUSTIBLE CONSTRUCTION IS PROVIDED FOR SEPARATION.

ROUTING OF THE NEW FEEDERS WOULD BE CLOSE TO AND PARALLEL TO THE EXISTING FEEDERS UNTIL IN THE IMMEDIATE VICINITY OF THE NEW TRANSFORMERS.

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ENGINEER'S SEAL

TENDER NO. 2007-

THE CITY OF WINNIPEG
WATER AND WASTE DEPARTMENT

Winnipeg

SOUTH END WATER POLLUTION CONTROL CENTRE

ELECTRICAL SITE PLAN

CITY DRAWING NUMBER: Figure 17.2

SHEET 1 OF 1

Discussion with Manitoba Hydro of the configuration, capacity, and coordination of the new feeder and the existing feeder are critical to the reliability of the Plant, and details should be formalized with Manitoba Hydro as soon as possible after the proposals are received. Construction by Manitoba Hydro can and should be completed and in place ahead of the Plant construction schedule. This is discussed in more detail in Section 17.6.

17.2.2 Pre-purchase of Transformers

Manitoba Hydro has specifically stated that they will not provide the additional transformers required for the expansion of the SEWPCC and so for the purpose of this report, it is assumed that the City will own the new transformers. Current delivery for mid-size power transformers is being quoted at 14 months to greater than 18 months. As a result, in order to avoid impact on construction schedule, Stantec recommends that the City consider purchasing the required transformers directly, to be handed over to the successful contractor for installation. This recommendation is discussed further in a later section of this report.

Sizing of the transformers will be confirmed during detailed design, but preliminary load information favors adding two matched transformers of the same size as the existing transformers. With the addition of tie buses and tie breakers this would provide a high level of reliability and redundancy for the Plant. The option of replacing the existing transformers with two new larger transformers has been considered, and is not preferred because it would produce higher fault currents, not provide the level of redundancy described above, it would be a departure from the standard transformer size stocked and supported by Manitoba Hydro, and it adds complication to constructability. Fault calculations will be undertaken by Stantec during detailed design, and a coordination study will be included in the specifications.

17.3 STANDBY AND BACKUP POWER

17.3.1 Standby Generators and Transfer Switches

The existing 1000 kVA natural gas fired generator is reported to be in good condition and reliable. It is not capable of handling the recorded peak loads.

A new generator will be added, synchronized with the existing 1000 kVA generator, to provide sufficient standby power for full Lift Pumping and operation of the essential Plant functions. The total generating capacity will not be designed to operate the full Plant, only the essential functions.

The essential loads are considered to include one large (500 hp) lift pump, one small (250 hp) lift pump, life safety systems, Plant control system, telephone system, essential lighting in all areas, and some specific HVAC equipment required for safe operation and to prevent damage to Plant equipment.

Stantec's recommendation at this stage is for a second, matching, 1000 kVA unit, intending that in the case that either of the two identical units fails or is out of service for maintenance, the other unit will be able to fully carry the essential loads. This sizing will be confirmed during detailed design once detailed load calculations are available. Transfer switches will match the dual feed configuration discussed above. Transfer switches will be designed for synchronous or "bumpless" transfer to allow the Plant load to be transferred to the generators during regularly scheduled exercising, and then back to Hydro without any interruption to operations. The provision of a load bank will be considered in the design, to provide for adequate exercise loading for the generators.

Under normal emergency power operation, both generators will run and be capable of supplying all four lift pumps and the other essential loads. With all lift pumps operating, the two generators running in parallel will have approximately 400 kW of spare capacity for the safety systems, Plant control system, telephone system, essential lighting, specific HVAC equipment, and other non-essential loads.

The existing 85 kW generator will be removed, to be replaced by a feeder from the new "Emergency Power Distribution" supported by the larger generators.

Loads will be configured and integrated with the Plant control philosophy to make allowance for the possibility of failure of one of the generators. The electrical distribution will be configured so that should future energy management functions, including "peak shaving" or load shedding become attractive or necessary in future, these functions can be added without difficulty.

Although current Manitoba Hydro rates and rate structure does not justify adding cost and complexity to implement measures such as using the generators for peak shaving, attention will be paid during detailed design, to transfer switch configuration and control so that in future, should it become attractive, the configuration would permit such use.

17.3.2 Uninterruptible Power Supplies (UPS)

UPS power will be provided to completely support the Plant Control System, instrumentation, network equipment, computers, telephone systems and alarm equipment. UPS capacity will be designed for "ride-through" of approximately 30 minutes to allow the generators to start and to allow for response in the case of a generator failure to start. The UPS units will be supplied by generator power, including the existing UPS, which is not currently supplied from a generator.

Where appropriate and practical, a centralized UPS supply, located in the new electrical room, will be designed to support the loads within an area. While centralizing the UPS power does not significantly reduce construction cost, it does improve reliability and reduces maintenance cost. In some locations where the UPS loads are small, stand-alone UPS units may be used where the cost of a centralized UPS is not justified.

17.3.3 Load Shedding and Long Term Operation Without Hydro Power

Generator capacity and configuration will be designed to supply essential loads, based on projected peak flows, on <u>either one</u> of the two 1000 kVA generators. In order to have the transition from “Utility Power” to “No Utility Power” occur automatically, control programming, transfer switch configuration, and load shedding through transfer switch interlock will be required.

Plant operation will be reviewed during detailed design to determine whether on a Utility Power Failure, if both generators start, synchronize and pick up load as intended, some additional process equipment can be activated. If one of the two main generators was unavailable or if it failed during operation, load shedding will occur in such a way as to keep only the essential systems operating. Prioritizing these systems will be undertaken in cooperation with the City during detailed design.

Once the automatic transition to a “No Utility Power” condition has occurred, operators will be able to assess the Plant operating state and generator loading, which will be displayed through the control system, and manually add back some non-essential loads if capacity permits.

Should long term operation without Hydro Power be required, operators can elect to operate on one of the main generators for a period of time and then switch to the other to permit maintenance and to equalize run hours. This operation will be operator controlled rather than automated; however, all generator synchronizing will be done automatically by the new synchronizing switchboard. This synchronizing switchboard will also provide the signals necessary to control load shedding.

17.3.4 General

The SEWPCC Plant has an existing split distribution system that, with the exception of the UV final treatment, provides an important level of redundancy. The split extends to each process area and is implemented by dividing the loads of each area between two Motor Control Centres (MCC). This configuration will be retained and expanded upon in designing the In-Plant Distribution to the new process areas and equipment, and to loads being changed in existing process areas.

Measurements taken in the main electrical room indicate that there is adequate space for installation of a new main secondary distribution centre. Feeders from this new 600 Volt distribution centre will be extended to the new loads, following the philosophy of dual feeds and dual MCCs.

Lightning protection and transient voltage surge suppression will be provided at the main distribution and at other locations as required to offer a high level of resistance to damage from electrical disturbances.

A new electrical room will be constructed to accommodate MCCs for the bioreactor air supply blowers and pumps, the clarifier drives and related equipment. The existing UV electrical room will be expanded as required to accommodate the additional UV load.

17.3.5 PowerSmart Programs and Energy Conservation

Through discussion with Manitoba Hydro and review of the currently available PowerSmart programs, Stantec has identified the following programs that have potential for benefit to the SEWPCC:

- Manitoba Hydro Power Smart **Commercial Lighting Program (CLP)** - light fixtures, exit signs & emergency battery banks.
  - Manitoba Hydro will rebate a portion of the cost of qualifying products used in new construction.
- Manitoba Hydro Power Smart **Performance Optimization Program (POP)** - motors, VFDs, air compressors, energy management.
  - Manitoba Hydro will contribute to the cost of studying (quantifying) the energy savings created through use of higher efficiency products. Application must be made, supported by calculation, at the early design stage.
  - One of the more significant areas for funding support is in the use of more efficient blowers, with both a contribution toward capital cost, and long term energy consumption cost saving.
- Manitoba Hydro Power Smart **Commercial HVAC Program** - boilers, chillers, condensing units.
  - Similar to the Performance Optimization Program, the Commercial HVAC Program offers partial funding toward the purchase of more energy efficient equipment. In order to qualify for this funding to the City, Stantec will have to provide analysis and supporting documentation to Manitoba Hydro.

During Detailed Design, as electrical loads and design details are confirmed, Stantec will calculate the value of each of the programs and the cost of documenting and implementing the program and make a final recommendations to the City on which programs to pursue.

17.3.6 Wiring Methods

Main feeder cables to MCCs and distribution panels will be aluminum conductor Teck 90 cable. Motor feeders to large motors may be considered in aluminum where there is significant cost saving over the cost of copper conductors. All branch circuit wiring #3 AWG and smaller, including all feeders to smaller motors and all lighting and general service branch circuits will be copper conductor Teck 90 cable, or, where construction conditions warrant, stranded copper conductors in rigid aluminum conduit. In general, feeder and branch circuit Teck cables will be run in aluminum ladder cable tray, separated from instrumentation and control cables.

Where underground or embedded in concrete runs are required, they will be run as Teck 90 cable or stranded insulated conductors in PVC conduit, transitioning to rigid aluminum conduit where they become exposed.

17.3.7 Motor Control Centres and VFDs

The existing Motor Control Centres in the Plant are Westinghouse. The Westinghouse line has been purchased and is now supported by Cutler Hammer. In order to have the simplest configuration for maintenance and the least cost in spare parts inventory it is recommended that Westinghouse/Cutler Hammer be pre-selected as the MCC type, provided that competitive pricing for both equipment and services can be confirmed with the supplier.

Specification of "Intelligent" MCCs is planned because they provide both reduced wiring cost, and better diagnostic and monitoring features than conventional MCCs. Cutler Hammer can provide either Profibus or DeviceNet configurations for the Intelligent MCC bus. As discussed in the Instrumentation section of this Memorandum, both Foundation Fieldbus and Profibus will be considered during detailed design. If Profibus is selected as the Instrument bus, then there are advantages to selecting Profibus as the MCC bus as well. If Foundation Fieldbus is selected as the Instrument bus, then the MCC bus can be either DeviceNet or Profibus.

New motor loads will be supplied and controlled from a combination of variable frequency drives and full voltage starters, grouped and mounted in the Motor Control Centres in the electrical rooms. Variable frequency (variable speed) drives will be ABB, conforming to the Plant standard.

Variable frequency drives will be configured with line and load side reactors and with terminating filters where required to control harmonics.

Existing VFDs will be reviewed to see if they can be upgraded to "intelligent" operation.

Motor drives will in general be standard high efficiency, inverter duty 600 volt induction motors. Small motors for small ventilation fans and metering pumps will generally be 120 volt single phase.

Power factor correction will be achieved, with a target of 97% to 98% using a combination of capacitors associated with large motors, and system trim using either fixed capacitors, or an automatic power factor correction capacitor bank at the main distribution centre.

17.3.8 Metering, Monitoring, and Protective Functions

There is existing power metering at a number of locations in the Plant, some of which is capable of being networked and monitored by the Plant Control System. Where possible this existing metering will be tied into the Plant Control System and new metering will be added at the new main 600 volt distribution centre to achieve a breakdown of energy consumption in the Plant. This allows both better load monitoring and planning and provides tools for energy cost reduction.

The option of primary metering will be reviewed once the Manitoba Hydro proposals are received.

In general, protection for distribution feeders and motor loads will be 600 volt air circuit breakers and moulded case circuit breakers. Circuit breakers will be lockable in the off position to meet WCB requirements.

Existing pumps, blowers and other rotating loads are presently provided with lockable E-Stop push buttons. This method for locking out equipment in the field by de-energizing the control voltage is inherently dangerous and in violation of code. All new equipment will be provided with lockable power disconnects designed to physically isolate any device from its power feed.

Ground fault protection will be provided where required by code and by good practice.

Fuses will generally be limited to high voltage protection, and to protection for I/O in instrumentation and control. For control system fusing, blown fuse indicating type fuse terminals will be used.

17.4 INSTRUMENTATION

17.4.1 General

Plant Operations has expressed a preference for use of bus-based instrumentation wherever practical. This will introduce a new technology to the Plant, one that can provide increased diagnostic detail and reduced commissioning time and troubleshooting time for those instruments that can be bus based.

The two competing "high level" plant instrument buses are Profibus and Foundation Fieldbus. Stantec recommends that, for simplicity, only one high level instrument bus be selected as the new standard for the City bus-based instrumentation. All of the options identified for upgrading and expansion of the Plant Control System can be compatible with either of the bus types.

Since most of the non-analytical instruments are available in bus-compatible versions and some of the analytical instruments are also available in bus-compatible versions, there will be a mix of bus-type and non-bus-type instruments. Stantec will work with the City during detailed design to make the final selection of which bus to implement, based on availability of instruments and cost to implement. (Please refer to the section above on intelligent MCCs for further discussion of buses).

17.4.2 Analytical Instruments

Analytical instruments for the Plant with inputs to the Plant Control System will include the following:

- pH and conductivity measurement of influent at the discharge of the Lift Station pumps, at the Hauled Liquid Waste Receiving station and in the Fermenter.
- Lower Explosive Limit (LEL) gas detection in the Hauled Liquid Waste Receiving room and in the receiving holding tank.

- Composite sampling at bioreactor inlets.
- Nutrient measurement (on-line nitrate and phosphate measurement) for the effluent lines, either upstream or downstream of the UV treatment.
- Oxygen Reduction Potential (ORP) probes and Dissolved Oxygen (DO) in aerobic Bioreactor cells.
- UVT measurement and UV intensity integrated with the new UV equipment.

17.4.3 Non-analytical Instruments

Non-analytical instruments for the Plant with inputs to the Plant Control System will include the following:

- Magnetic Flowmeters measuring influent flow by measuring flow at the Hauled Liquid Waste Receiving station, output from each Raw Sewage Lift Pump, bypass flow and recycle flow in each bioreactor and flows to UV disinfection.
- Flow into the bioreactors.
- Thermal Mass Flowmeters measuring air flow to sections of the bioreactors.
- Chemical feed systems will have positive displacement flowmeters where required, and there will be vendor supplied instruments on polymer mixing skids as required for operation.
- Open Channel Flowmeter measuring final effluent flow and for measuring flow in each of the channels to the primary settling tanks (PST). These Open Channel Flowmeters may incorporate level measurement as well.
- Temperature in influent flow, and ambient temperature monitoring for heating failure in new buildings, temperature in the heat recovery system, and temperature measurement in the Fermenter.
- Pressure on pump suctions and pump discharges.
- Level by ultrasonic instruments or by radar in the influent wetwell, in the blend tank in the scum tanks, and in the underground hauled liquid waste storage tanks.
- Sludge blanket thickness in PST and Secondary Clarifiers and in the Fermenter will be submerged ultrasonic.
- Sludge density will be measured between the DAFs and the sludge storage.

17.4.4 Instrument Wiring and Identification

In general, instrument cabling will be run as jacketed armored cable in separate dedicated instrument cable trays with the last section of each run supported on structure or corrosion resistant mounts to water-tight connectors at the instrument. Where underground or embedded in concrete runs are required, they will be run as jacketed armored cable in PVC conduit, transitioning to rigid aluminum conduit where they become exposed.

The existing Plant instrument numbering scheme will be used and extended to the new process instruments. Stainless steel permanent tags will be attached to each instrument, motor, MCC, UPS and other equipment showing the instrument identification number.

17.4.5 Instrument Calibration

Some instruments, including a number of the analytical instruments, can be field calibrated. This typically includes setting zero and span or range and offset. For instruments designed to be field calibrated, the design will call for this work to be done and documented by a qualified manufacturer's representative, and witnessed by the Engineer and the Owner. Calibration procedures will form part of the training for Operators, and calibration procedures will be included in Operations and Maintenance Manuals.

Other instruments, including flowmeters and some pressure and temperature instruments, are factory calibrated, and calibration can not be changed in the field. For these types of instruments, a factory calibration certificate must be provided, and then the calibration will be verified at time of commissioning, either by comparison with a calibrated test instrument, or by empirical methods. Where the Environmental Licence #2716 requires re-calibration of flowmeters every two years or as required by an officer, this clause needs to be discussed with Manitoba Conservation and reworded to specify verification rather than re-calibration. In order for these flowmeters to be re-calibrated, they would have to be removed and shipped back to the factory. This would cost almost as much as replacing the meters every two years.

17.5 BUILDING SYSTEMS

17.5.1 General

Distribution within buildings will generally be 600 volt 3 phase, with step-down transformers provided locally for some lighting (general lighting is 347 volt), receptacles, controls, instrumentation and other 120 volt loads. HVAC equipment and lighting will be backed up by the standby generators except where it is considered non-essential

17.5.2 Lighting

In new indoor and outdoor areas, where lighting is required to be on continuously or for extended periods, the lighting will generally be Metal Halide. Consideration is being given to the use of new Light Emitting Diode (LED) type fixtures in some areas.

The current lighting in the plant is turned on 24 hours per day, 7 days per week, while the plant is only typically manned for 40 hours per week. The Power Smart program offers a small credit for the installation of occupancy sensors for lighting control, but no overall incentive for a lighting control system. Lighting in the main areas will be designed for two lighting levels where appropriate to reduce energy consumption and extend lamp life. Exterior lighting will have photocell control.

17.5.3 Emergency Lighting

Emergency lighting will be provided in all areas where it is required for safety. In areas lit by High Intensity Discharge (HID) lamps where the HID lighting is supported by generator, the fixtures will be provided with "quartz restrike" lamps to match the existing installation.

17.5.4 Fire Alarm

New fire alarm zones will be created in accordance with the Fire Code, with area panels connected to the central fire panel. The main fire alarm annunciator panel will be upgraded to show the new zones, and existing zones will be modified as required to correctly represent the new Plant layout.

The new sections and panels will be addressable type and new fire detectors, smoke detectors heat detectors and pull stations will be designed to meet or exceed code requirements.

The City has indicated that the existing central fire alarm panel may require replacement.

17.5.5 Security and CCTV

Stantec was expecting to receive from the City an evaluation of the Plant security as a part of the Risk and Criticality Assessment. However, plant security was not reviewed as part of the Risk and Criticality Assessment. Plant security was not a part of Stantec's Conceptual Design scope of work either. Therefore, the facility security requirements will be developed as part of the Detailed Design. Once these are developed, security equipment will be designed in accordance with the decisions.

It has been determined that Closed Circuit Television (CCTV) cameras specified for night operation at the Hauled Liquid Waste Receiving station and where required for security will be added to the existing CCTV system.

17.5.6 Telephone

Telephones will be provided in the new process areas for operator communication, and in the new electrical room and shop area. The phones will be connected to the existing PBX (exchange), which will be expanded as necessary to accommodate the new connections.

Stantec recommends that new telephones be provided in new electrical rooms and shop areas, at new DCS cabinet locations and at operator stations.

There is a requirement both to improve the existing poor quality voice telephone outside lines serving the plant and to provide new capacity for data connections. During detailed design, Stantec will define the requirements and assist the City in applying for the required upgrade of service.

17.5.7 HVAC Power and Control

As indicated earlier in this section, generator power will be supplied for HVAC systems considered essential and not for those systems considered non-essential. Conceptual load calculations show approximately 400 kW of capacity will be available for these functions. The available emergency power and list of essential loads will be defined during detailed design.

Control for HVAC systems will be kept simple, with local control where appropriate and monitoring of ventilation and temperature. Some HVAC alarms will be integrated into the Control System for operator convenience and response.

17.6 CONSTRUCTION STAGING CONSIDERATIONS

17.6.1 Main Service Staging

Recent information from Manitoba Hydro indicates that the cables feeding the existing two 2500 kVA transformers are not a risk factor as was previously thought. This means that cable replacement will not have an impact on project scheduling, provided that Manitoba Hydro's upgrading work can be completed before construction starts.

The intent will be to design the new transformers and feeders to be built without interrupting power to the Plant except for one or two very short outages for tie-in, each in the order of half a day. Installation of the tie-breakers discussed in the "Pre-purchase of Transformers" section will require one slightly longer interruption, likely one full day. These interruptions will be coordinated with low flow conditions to minimize the risk of any upstream overflows from the collection system.

17.6.2 New Equipment Power and Control

The design intent will be to have the new electrical room at an advanced state relatively early in the construction schedule so that new equipment installed in the new process areas and connected to the new MCCs can be tested, adjusted, and used if required, well before construction is complete.

This will also assist in providing construction power and lighting to new areas.

Constructability for new equipment fed from existing MCCs, and any impact of demolition will be reviewed when more detailed information is available in the later stage of detailed design.

17.6.3 Backup and Standby Power Staging

Timing of Backup and Standby power is not critical to construction, but must be completed before startup and commissioning. When the new paralleling switchgear is installed, there will be a period of time when the standby generator is disconnected. This period should not exceed two or three days. The City has advised that based on their experience with power reliability, and the operational provisions which they have for a total outage, it will not be necessary to provide for an alternate standby generator. The cut-over is to be scheduled for a "low risk" period, when high flows are not expected.