TECHNICAL COMMITTEE MEETING
Wednesday, January 29,2014
2nd Floor Conference Room
Plant Site, 111 Harbor View Avenue, Stamford, CT 06902

5:30 p.m.

Attendees:

Dan Capano	Chairman, Technical Committee
Daniel Schwartz	Committee Member
Cristina Andreana	Chair Finance Committee
William Brink	Executive Director, WPCA
Prakash. Chakravarti	Supervising Engineer, WPCA
William Degnan	Plant Supervisor, WPCA
John Braccio	Wright Pierce
Christopher Pierce	Wright-Pierce

1. **Call to Order, Pledge and Roll Call**
   Chairman Dan Capano called the meeting to order at 6:30 pm.
2. **Review and approval of previous meeting minutes.**
   D Schwartz made a motion to approve the meeting minutes for December 16, 2013 seconded by D Capano. The motion was carried 2-0-0.
3. **Presentation on Soundview Avenue interceptor rehabilitation—Wright Pierce**
   C Pierce of Wright-Pierce did a Powerpoint slide presentation on the condition of the 36" and 42" reinforced concrete sewer pipe in Soundview Avenue. He and J Braccio stressed the urgency of rehabilitating about 3000 linear feet of the sewer pipe. W. Brink noted the budget available for sewer rehabilitation is approximately $1.3 million and he requested a cost estimate based on a phased approach based on need. (Printout of the Powerpoint slide presentation is being made part of the meeting minutes)
4. **Presentation on scope of work to evaluate upgrade of the Raw Sewage Pumping Station --- Wright-Pierce**
   C Pierce of Wright-Pierce did a Powerpoint slide presentation on the scope of work Wright-Pierce would provide and briefly outlined the upgrade to influent screens with fine screens and wash system to dispose of the screenings as household waste, septage receiving, replacing the pumps with higher efficiency and capacity and modifying the existing odor control scrubbers to double the capacity by changing the scrubbers operation from series to parallel operation and also using carbon filter system in the towers. (The slide presentation is being made part of the minutes)

5. **Engineering Services Agreement for Upgrade of Raw Sewage Pumping Station**
   B Brink handed out the Engineering Services Agreement with Wright-Pierce for upgrading the Raw Sewage Pump Station. D Capano asked to defer the discussion and review until the next Technical Committee meeting

6. **Engineering Services agreement for improvement of Flow Distribution to Secondary Clarifier**
   B Brink handed out the Engineering Services Agreement with Hazen Sawyer for improvement of Flow Distribution to Secondary Clarifier. D Capano asked to defer the discussion and review until the next Technical Committee meeting

7. **Odor Control**
   C. Pierce described the scope of work to design modifications to the odor control exhaust ductwork inside the sludge dewatering building to improve the capture and removal of odors from the belt filter presses, the sludge strain press and sump pump in the truck loading area. B Brink explained that odor controls in the sludge processing building has been significantly improved with the opening of the closed fire damper on the ductwork ventilating the sludge blend tank.

8. **Engineering services for design of duct work modifications in the sludge dewatering building**
   B Brink stated that Wright-Pierce has submitted a price proposal to design the ductwork modifications in the sludge processing building. They are requesting $18,500 for providing the design. D Schwartz made the motion to approve the $18,500 for the design of the ductwork in the sludge processing building, seconded by D Capano. Motion carried 2-0-0

9. **Operation and Maintenance agreement for the Sludge Drying Facility and Dried sludge disposal**
   B Brink stated that the contract is in review by the Department for Legal Affairs and would like the Technical Committee to approve it for him to present it to the Board of Directors for approval. D Schwartz made the motion to approve the agreement subject to review and approval by the City Corporation Counsel. D Capano seconded the motion. Motion carried 2-0-0

10. **Update on screenings and grit disposal**
    In reference to the screenings and grit tub carriers, P Chakravarti stated that in 2011 he had obtained price quotes for two types of tub carriers on the market that serves the purpose of picking up the tubs and dumping it in the trailer.

    One was a light duty unit for $127,194.42 by Stellar Industries and the other was a heavy duty type for $128,869 by Dempster Dumpster. The Stellar unit can pick up a three yard tub whereas the Dempster Dumpster can pick up a five yard tub. P Chakravarti handed out a single page with pictures of the two units. He mentioned that currently City Carting is providing the service of dumping the tubs every day at $80 per day. W Degnan asked if it was prudent to procure the carrier now or postpone the purchase until the upgrade of the influent pump station is completed at which time there may not be a need for the carrier. The committee decided to postpone the purchase.

11. **Update on design and construction projects**
P Chakravarti stated that the scope of design services has been presented to the Committee for Task 1 and Task 2 of the Engineering studies for upgrading the influent pump station and flow distribution to the secondary clarifiers. Plans and specifications for the pipe supports in the influent pump station and the operations building are ready to be sent to purchasing for advertising for bids.

The scope of services for replacing the sludge transfer pumps will be ready for review soon.

Design of Wedgemere sewers and Perna Lane sewers are about eighty to ninety percent complete.

Construction on the Carriage Drive sewer project is about 55 percent complete and it is anticipated all sewer construction will be completed by end of April 2014. The roadway will be paved by end of June 2014.

12. **Submission of WIFI POC Proposal for committee comments-Dan Capano**
D Capano handed out a proposal he put together for the committee to review and comment. He mentioned that there will be significant cost savings and the WiFi communications are safely encrypted. He would like the committee to read and understand the proposal and send comments to him. He would like to present the proposal of the pilot project to the full Board at its February, 2014 meeting.

13. **Old Business**
There was no old business to discuss other than the above items.

14. **New Business**
B. Brink briefed the committee on the recent exceedances of the plant permit due to malfunction of the UV disinfection system. He mentioned the recurring problem is due to the system reacting to erroneous water level signals. The water level sensors, wiring and connections to PLC have been replaced and the manufacturer's service technician was coming to the plant the next day to inspect and test the UV system to resolve the issue.

There being no other new business to discuss D Capano asked for a motion to adjourn the Technical Committee. D Schwartz made the motion to do so. Motion carried 2-0-0. The meeting was adjourned at 9:30 pm.

Attachments

1. Powerpoint presentations by Wright-Pierce
2. WIFI POC Proposal for committee review

RedZone Inspection Status and Soundview Interceptor Rehabilitation

Presented by:

Joe Hausmann, P.E.

WRIGHT-PIERCE
Engineering a Better Environment

Presentation Overview

- RedZone Inspection Project Scope
- RedZone Inspection Current Status
- Soundview Avenue Interceptor
- Additional Areas of Concern

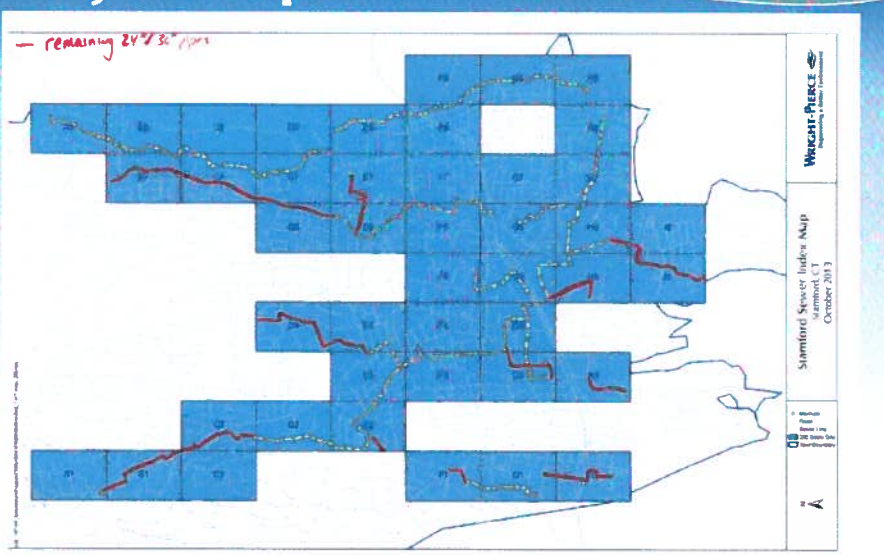
Inspection Scope

- Laser/sonar/CCTV all pipes 24" dia and up
- Approximately 100,000LF

- Currently Approximately 70,000 LF has been inspected
- Approximately 30,000LF of logs and videos have been received

3

Project Scope



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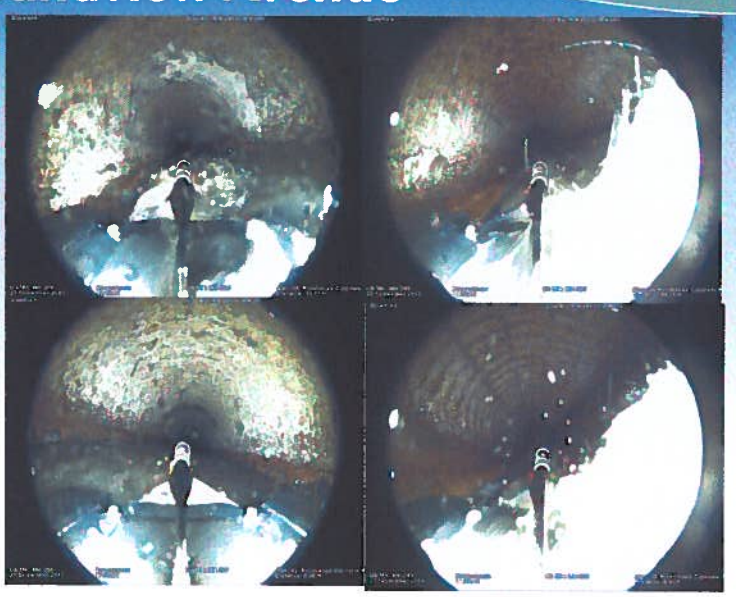
Soundview Avenue

5

Soundview Avenue



6

Soundview Avenue

- Line approximately 3,000 LF from end of Wallacks Point lining to McMullen Avenue.
- Previous cost estimate of $1.5 million seems reasonable for budgeting purposes.

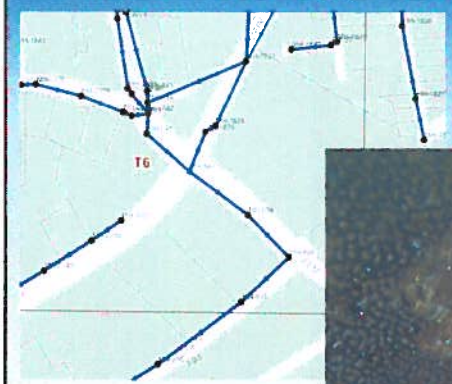
7

Additional Areas

- We received an additional 10,000 LF of video last week.
- We've been able to quickly preview about 50% of the additional videos.
- In that 5,000 LF of video we identified a few potential urgent areas:

8

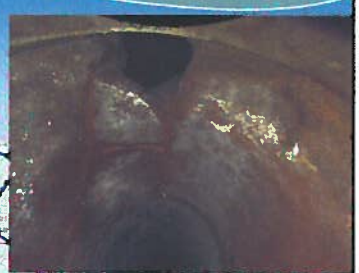
Additional Areas



Elm Street - MH-840 to MH-838 - 30-inch concrete pipe

9

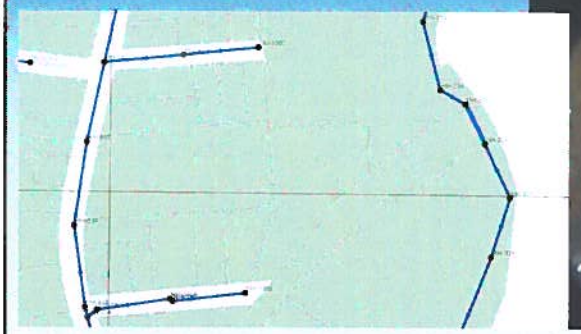
Additional Areas

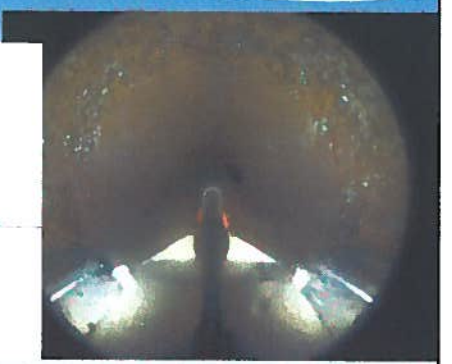


Alvord Lane - MH-134 to MH-130 - 30-inch clay pipe

10

Additional Areas





- Railroad crossing
- MH-335 to MH-336
- Needs more inspection to confirm remaining pipe thickness

11

Questions / Discussions

Upgrade of Screenings Removal, Raw Sewage Pumping and Septage Receiving

Presented by:

John Braccio, PE
Christopher Pierce, PE

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Presentation Overview

- ✓ Screenings removal evaluation
  - ✓ Bar spacing
  - ✓ Screenings handling
- ✓ Raw sewage pumping alternatives
  - ✓ Pump capacity
  - ✓ Pump replacement
- ✓ Grit removal
- ✓ Septage receiving
- ✓ Generator evaluation

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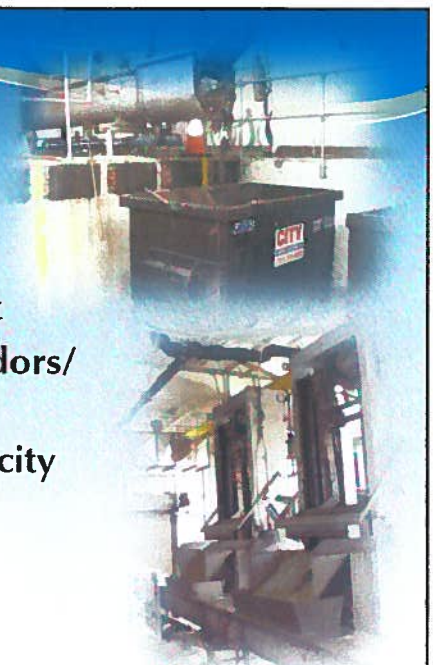
Project Understanding

- Screening System
  - rags & debris get to downstream equipment
  - unwashed screenings odors/ disposal costs
  - screenings storage capacity
  - flooding of bar screen



Stamford, CT On-Call - Task 1, Slide 3

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Project Understanding

- Raw sewage pumps
  - aging equipment/pump capacity
  - overflows at primary flow splitter
  - odor control/corrosion
  - pipe/valve condition
- Septage receiving facilities
  - pretreatment
  - fugitive odor release
- Feasibility for grit removal?
- Generator improvements

Stamford, CT On-Call - Task 1, Slide 4

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Key Issues – Screenings System

- Screenings handling
  - currently hauled to landfill - $
  - grinder wash press – allows disposal as municipal solid waste (MSW)
  - DEEP M.O.U.
    - ground, washed compacted and "unrecognizable" screenings
    - less costly to dispose
    - helps reduce odors
    - reduces volume

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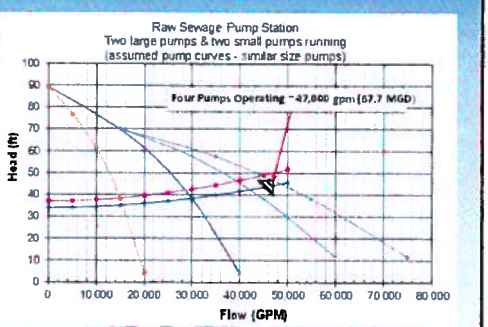
Key Issues – Raw Sewage Pumping

- System capacity
  - Determine actual pump capacity
  - Periodically five pumps in service
  - Temporary flow metering
- Permanent flowmeter



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Key Issues – Raw Sewage Pumping

- Pump replacement
  - energy efficiency
  - Pump capacity
  - Pump style
  - CL&P incentives

Stamford, CT On-Call - Task 1, Slide 7

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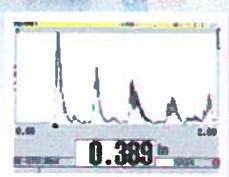
Key Issues – Raw Sewage Pumping

- Associated Systems
  - pipe supports – being replaced
  - condition of existing piping/ elbows due to grit
  - existing electrical systems
    - Generator(s)
    - Fuel tank capacity
  - existing controls
  - odor control
  - grit removal



Stamford, CT On-Call - Task 1, Slide 8

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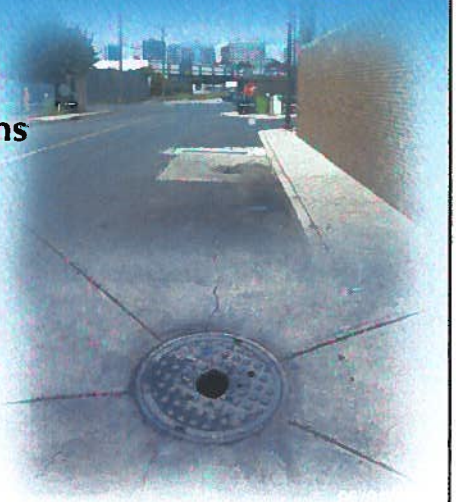
Key Issues – Septage Receiving

- Septage pretreatment
  - discharge to bar screens
  - no rock removal
  - no grit removal
  - potential fugitive odor emissions



Stamford, CT On-Call - Task 1, Slide 9

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Key Issues – Septage Receiving

- Septage alternatives
  - pretreatment w/screening
  - screening/grit removal
  - contain odors
  - New building needed?

Stamford, CT On-Call - Task 1, Slide 10

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Key Issues – Odor Control

- Functional system
  - repair/replace piping & equipment
- Two parallel units
  - additional odor control capacity

Stamford, CT On-Call - Task 1, Slide 11

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Key Issues – Odor Containment

- Screens, channels/ wet wells
  - improve sealing of channels
  - improved air flow
  - concrete rehabilitation
  - protective coatings
- Put influent sewer under negative pressure

Stamford, CT On-Call - Task 1, Slide 12

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Project Approach

- Preliminary planning
  - meet with WPCA staff to confirm scope
  - develop draft agreement
  - meet with CT DEEP
    - maintain funding eligibility
    - authorization to initiate study

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Project Approach

- Conceptual Design
  - update flow projections
  - evaluate alternatives
  - develop recommendations
- Preliminary Design
- Final Design
- Bidding
- Construction Administration

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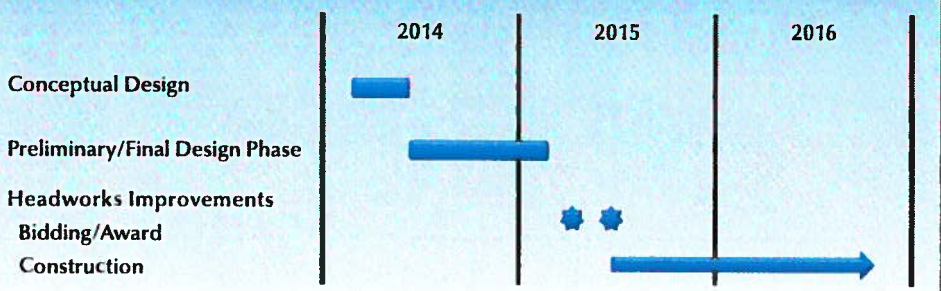
Anticipated Project Schedule



Stamford, CT On-Call - Task 1, Slide 15

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Engineering a Better Environment

Questions / Discussions

PROPOSAL
FOR THE DESIGN AND IMPLEMENTATION OF AN OPEN 802.11 SCADA NETWORK AT THE STAMFORD WATER POLLUTION CONTROL FACILITY

Prepared by
Daniel E. Capano

FOR THE
STAMFORD WATER POLLUTION CONTROL AUTHORITY
BOARD OF DIRECTORS

January 26, 2014

CONTENTS PAGE

SUMMARY	2
TECHNICAL BACKGROUND	3
CONCEPT OF DESIGN	7
SECURITY	10
TESTING METHODOLOGY	11
COST ANALYSIS	12
PLANT-WIDE DEPLOYMENT	14
EXHIBITS	16 (following)

SUMMARY

The Stamford Water Pollution Control Authority (SWPCA)is soliciting proposals to upgrade an aging and proprietary SCADA (Supervisory Control And Data Acquisition) System, Particularly the Remote Transmission Units (RTUs) and selected field instrumentation. Research into existing RF communication links integral to the collection system has triggered a discussion and formulation of a concept whereby existing field instrumentation could be monitored and controlled utilizing an open 802.11 network (WiFi) for communication, replacing conventional wiring to the instrument locations.

This proposal discusses the concept of design and a method of implementation using readily available, enterprise wireless equipment to form a secure and reliable network without reliance on conventional bounded communication methods. It is expected that a full implementation of this concept would result in significant cost savings as the individual cable runs and required electrical conduit, with the requisite labor and maintenance costs, would be substantially reduced or eliminated.

Future expansion costs would also be substantially reduced; the wireless network architecture allows flexibility in instrument placement without the need to install additional wire and conduit to a new location. Additional benefit would be the ability of the wireless network to handle plant wide communication traffic, allowing seamless and reliable communication between plant personnel and delivery of wireless multimedia to facilitate efficient maintenance and repair of process equipment. Security and life safety monitoring implementations will also be possible at a reduced cost. Future expansion of the wireless network is infinitely scalable and would require no further data wiring, also resulting in reduced deployment costs.

This proposal describes a proof of concept implementation on a small scale that will provide valuable data for eventual expansion into a complete plant-wide network.

Primary Goals:

- Cost Savings: Wireless technology will save money. Installation costs compared to wired networks will be 50-75%. Long term maintenance costs are negligible
- Process Monitoring: The main purpose of this project is to demonstrate the ability of a wireless medium to replace a costly wired network.
- Flexibility: Wireless networks are scalable and flexible in implementation. Wireless devices can be installed practically anywhere and the system can easily be expanded at minimal cost.
- Security: Modern wireless technology is protected by robust security methods based upon the federal standard FIPS -197 Advanced Encryption System (AES)
- Mobility: Operators can be anywhere within the facility and will be able to monitor any plant process from a mobile device, requirements for a central control facility will be reduced.
- Efficiency: Wireless networks afford an operator the ability to bring critical information to their location, rather than leaving the job site to locate the material which results in lost time.
- Communication: Reliance on costly subscriber based communication or expensive and proprietary communication systems will be eliminated.
- Safety: A wireless network will facilitate the placement of life safety, surveillance and asset tracking systems for complete monitoring of personnel and equipment.

TECHNICAL BACKGROUND

Wireless Technology Overview.

WiFi Technology has matured significantly since it was introduced approximately 12 years ago. At that time, the technology suffered from easily compromised data security methods and slow data rates. The wireless segments of conventional bounded (wired) networks were considered inherently unsecured, and were not used for critical or confidential data traffic. Subsequent efforts by the IEEE (Institute of Electrical and electronic engineers) and the WiFi Alliance resulted in greatly improved data security and higher data rates, resulting in an explosion in the development and deployment of wireless LAN (WLAN,802.11) devices. Presently, the technology is experiencing a significant leap forward in speed with the introduction of the 802.11ac standard, which will allow data rates in the Gigahertz range.

Integration with conventional wired networks is a standard feature and allows seamless incorporation of wireless access points (APs) into any existing wired network with a minimum of configuration issues. The foundation of the concept of a wireless network segment is the ability of wireless devices to access network resources on a wired network through a wireless AP, which acts as a portal into the bounded network. It can be readily seen that without reliable security methods, a wired network and its resources could be compromised and damaged; valuable data can be stolen or manipulated for nefarious purpose.

There are several different types, or topologies, of wireless networks. The most basic, and the configuration most people are familiar with, is the SOHO (Small Office, Home Office) wireless router, or the wireless router supplied by a telecommunication vendor such as a cable provider. These are standalone, or Autonomous APs. Typically, a SOHO implementation requires a single portal (AP) and is sufficient for this use. This implementation is known as a Basic Service Set, or BSS.

In some small businesses, there is a need for greater capacity and coverage. These terms will be explained in more detail later in this document. In order to achieve this requirement, it is necessary to add additional APs; additional APs are typically configured with the same naming and security parameters as the primary AP. This arrangement is known as an Extended Service Set, or ESS. An ESS affords the users (clients) the ability to roam to different locations within the coverage areas without losing network connectivity. Utilizing sophisticated algorithms, APs communicate with one another using either a wired or wireless medium to facilitate a seamless hand off of the mobile wireless device from one BSS to another. This is done securely and within several microseconds, depending on the type of traffic between the devices.

As the small business becomes an enterprise, the need for greater coverage and capacity also increases, resulting in more APs to handle traffic over a larger physical area, as well as a greater density of users. Now, a word about coverage versus capacity: Coverage is simply the size of the AP's “cell”; traditionally, this cell is traditionally shown as an octagon that adjoins octagons of other AP coverage areas. This is done to simplify the planning process when designing a network; in reality, and owing to a variety of environmental factors, the coverage area may more closely resemble the form of an amoeba. In the coverage area, the number of users may vary greatly, and this will have a significant impact on data throughput. It follows that if more users are accessing the portal, available bandwidth will shrink in proportion, resulting in slower data rates for all users. The end result is that coverage and capacity do not readily correlate. Speaking in relative terms: in a coffee shop with free WiFi, coverage

is more important than capacity, whereas in a on office environment, capacity is more important than coverage. It is therefore more desirable to have more APs in an office environment, allowing lower user density per AP, resulting in higher aggregate data rates for all users.

As previously mentioned, coverage areas vary greatly owing to environmental factors. RF energy is subject to attenuation (decrease in signal strength) in varying degrees from different types of building materials. Concrete, water, and metal walls greatly attenuate RF, and this factor must be considered when planning a wireless network. Electromagnetic Interference (EMI) from both 802.11 and non-802.11 sources will also degrade the signal. Finally, the applications and type of data traffic being used require different data rates to avoid corruption or poor delivery; modern wireless networks prioritize traffic based on a tolerance for latency in data delivery. Voice and Video traffic require low latency and higher bandwidth to prevent poor delivery of data, resulting in corrupted video or voice. Data traffic, such as file transfer or low bandwidth data (such as process data) is latency tolerant and will tolerate lower data rates and EMI without corruption.

It should be noted that 802.11 communication is “half-duplex”. This means the AP and client device (the mobile device) do not communicate at the same time. One device transmits, then the other – but not simultaneously. Simultaneous two way communication between devices is called “full-duplex”; telephone communication is full duplex. The actual useable aggregate data rate, that is, the combined rate of data transfer from all users of an AP, is the actual throughput and will never exceed half of the advertised maximum data rate. Data throughput is affected by many factors, including the method of contention for use of the medium, a discussion of which is beyond the scope of this document.

Wireless architecture is another concept that must be understood in order to fully comprehend the capabilities of the technology. Architecture, as referred to a wireless network, describes several different parameters. The first is the method of channel allocation; wireless networks can be constructed as single- or multichannel networks. In the first case, a single wireless channel is assigned to the network and all APs broadcast on that channel. The client devices see only one AP regardless of where they are in the facility, and roam seamlessly from one AP to another based upon algorithms unique to to the network vendor. In a multichannel arrangement, several coverage cells are arranged contiguously within the facility using different channels. In the current 802.11 2.4 Ghz implementation, this requires the use of three non-overlapping channels; in the 5ghz implementation, a total of 23 non-overlapping channels are available. In a multichannel architecture, the client devices will roam based upon signal quality and will invoke sophisticated and standardized methods of association and re-association with neighboring APs.

Another aspect of system architecture is the method of network control. Currently, there are three types of control methodology: Autonomous, controller based, and cooperative. Autonomous networks are,in their simplest form, a group of interconnected APs (an ESS). Depending upon the size of the network, there may also be some form of centralized management and control, though this has proven unwieldy and unreliable. Autonomous networks rely on the APs, “at the edge” of the network, to perform all security and data management, using the wired link, or backhaul, to effect data transfer and client roaming between devices.

Controller based networks utilize a central control device to manage data traffic, roaming and AP coverage and capacity issues. Controller based networks typically require both the controller and the APs be from the same vendor, effectively locking them in. The APs are also typically “lightweight”;

this means that most of the system intelligence resides in the controller, and the APs are reduced to radio capable network portals. The controller can dynamically control transmit power and channel assignment, as well as client access and roaming. The major downside of this type of network is that it presents a single point of failure; another is the proprietary nature of the system. Controller based networks are well suited to facilities that have a large installed wired network in place; replacement of existing autonomous APs can be easily done and control facilities located within secure data centers.

The third type of wireless network architecture is called Cooperative Architecture. This type of network can be thought of as a hybrid of the previous two types described. In cooperative architecture, autonomous APs are deployed in order to maximize wireless coverage throughout a facility. Instead of having a centralized point of control, each AP "cooperates" with the neighboring APs in order to effect control of the network function. Each AP communicates with its neighbor either through the wired infrastructure or wirelessly to exchange network status and client information. Client roaming is handled between APs, instead of through a controller, as in a an autonomous network. The network can be managed centrally, but in this context means that any wireless capable client running the appropriate software can access the network and the individual APs to effect configuration, maintenance or troubleshooting.

The major advantage of this type of architecture is there is no single point of failure; the loss of a single AP does not compromise the entire network, and there is no central control facility to compromise or fail. A properly designed cooperative network will automatically compensate and possibly adjust coverage area for a failed AP. Cooperative wireless networks are easily scalable, allowing the addition of APs over several phases. The APs form a full "mesh" network, and as new APs are brought online, they are integrated into the existing network. Another advantage to this type of system is the ability to eliminate data cabling to remote locations. While this feature is also possible in the previous architectures to varying degrees, the cooperative architecture is particularly well suited to this benefit by definition. A dual band (2.4, 5 GHz) AP will typically communicate with client devices on one band while providing control and backhaul on the other. In other words, a field device could communicate on the 2.4 GHz band while data transfer and network control is simultaneously occurring on the 5 GHz band.

Instrumentation Overview.

The other component of the proposed system is field instrumentation. Traditionally, field instrumentation relies on proprietary communication methods or on point to point, dedicated wiring to either a marshaling point for translation and interface to a wired network, or to a dedicated control panel, which may or may not be integrated into plant-wide network. These networks are known by different terms, the most common being SCADA (Supervisory Control And Data Acquisition), or Distributed Control Systems (DCS). Many of these specialized networks, while relying on conventional wired networks for communication, are proprietary in nature, using an interface with field instrumentation peculiar to their systems. This has been the case for many years and has succeeded to varying degrees based upon many factors including design and implementation, end user staff, and vendor support or viability. Presently, outside of manufacturing, the concept of "big iron" SCADA systems is being re-examined and affords an opportunity for new technology to present itself.

At this writing, a minority of instrumentation vendors offer an RF solution; of those that do, the majority are proprietary links or protocols. Many end users frown on proprietary or "sole-source" solutions such as these and will agree to implement these systems if they can be proven to fulfill a specific need or task that no other vendor can address. It remains, though, that wireless is not being implemented in many facilities because of of several issues previously discussed, top among them being Reliability and Security.

Normal SCADA traffic is low bandwidth and is low priority in terms of Quality of Service (QoS) considerations. Very few processes require the type of "mission critical" response times that would suffer from signal latency and create a life safety hazard. A delay of 800 microseconds would still be within the allowable time for a critical process to both report a problem and automatically shut down (if centrally controlled). In a properly designed DCS, local control systems handle all critical shutdown and alarm functions and thus would not be subject to reliability or security issues. Alarms, process variables and other event indications are the prevalent form of traffic and as previously stated, is low bandwidth and latency tolerant.

A large part of the implementation of this concept will be education. Typical facility staff understands wired networks to varying degrees; very few have the credentials to be an effective IT or control systems practitioner, however. The good news is that those who are in the higher echelons of these facilities do have an advanced level of understanding of the technology. It is important to familiarize the end user to the capabilities of a wireless network beyond the obvious and widespread use – accessing the internet from a smart phone. Illustrating the capability of the network to facilitate flexibility, scalability and cost savings is the first step in allaying the inherent objections many end users have.

Additional Benefits.

Other services of great value to the end users is the capability to deliver voice and video to a remote or mobile device. Aside from the low bandwidth traffic associated with monitoring and control systems, a seamless and reliable voice capable network will allow low cost communication to be achieved between plant managers and staff. Broadcast (all phones)and unicast (single phone)traffic is easily achieved and would facilitate easier communication within the plant bounds. Location services will also be used to track personnel or equipment for better management.; this capability could be extended to inventory control and asset tracking. This feature could eventually replace the wired public address systems currently in place with stand alone, wireless "squawk boxes" strategically located.

Another trend that would benefit greatly from wireless technology is the growing use of Computerized Maintenance Management Systems (CMMS). The idea behind these systems is to generate a database of equipment installed in the facility and centrally manage the maintenance program for each. Generally, a central server runs a CMMS program and generates work orders for maintenance tasks. Typically, a kiosk or terminal is located in several areas of the plant accessible by staff for pertinent information regarding the maintenance task, i.e.: operation and maintenance manuals, vendor instructional videos, maintenance history records, or simply to access or enter information for that specific task.

This data could now be delivered to a tablet or smart phone that is mobile throughout the facility, eliminating the need for wired terminals at a fixed location; the technician could access all required

information for that equipment without lost time searching for that information in files or at a location removed from the equipment. Also, the staff member could clock into and out of that task in order to provide cost tracking data to management, providing valuable metrics for future budgeting and maintenance discussions.

Finally, security and life safety monitoring can easily be achieved by the use of wireless IP (internet protocol, “addressable”) cameras and wireless capable monitoring devices such as hazardous gas monitoring systems. The flexibility of the wireless network would allow placement of devices in remote locations where wired data connections are not available.

CONCEPT OF DESIGN

The purpose of this implementation would be to demonstrate a wireless DCS on a small scale utilizing a cooperative wireless network architecture. Initially, a non-critical process with varied data acquisition will be chosen to demonstrate the concept. In order to keep initial cost to a minimum, the primary/sludge OCS will be used as a source of process data to be monitored. The OCS affords the opportunity to interface with several different types of instruments and devices. The location of the system, being approximately 300 feet from the Administration (Operations) building, would provide an opportunity to prove out a point-to-point RF link and the reliability thereof. Using a dual band AP and directional, or semi-directional antennas, local field devices would communicate with the AP in the 2.4 GHz band, which in turn would communicate point-to-point with another AP located in the Admin building on the 5GHz band. In turn, another AP would be placed in the control room for dedicated communication to the exterior AP, removing the requirement of a wall penetration and associated labor. This arrangement allows for easier expansion to the primary settling tank complex adjacent, and then to the thickener complex adjacent to that by adding an additional AP. As can be seen in the attached maps, RF coverage will be provided to several areas surrounding the primary tank and thickener areas. Owing to the attenuation associated with brick and concrete, penetration into the thickener building is limited.

Each OCS process has a minimum of four separate instruments, monitoring pH, ORP, Level and Flow. Each variable is locally controlled, so only the process variable would be monitored and no control would need to be effected at this point. These installations have suffered from unreliable dedicated wiring in the past, and this would be a viable alternative to traditional wiring. There are two OCS, each with identical instrumentation. The instruments utilize standard 4-20ma control signals that will be converted into a wireless format. Individual equipment will be discussed in a later section.

Control room equipment would consist of a wireless receiver interfacing with a dedicated PC using a network interface. Integration with the plant SCADA system will be accomplished in a full deployment, the means and methods of this integration is beyond the scope of this document. The overall plant layout and OCS Process & Instrumentation Drawing (P&ID) attached to this proposal. RF field strength and data rate maps for each frequency used are also attached.

Equipment

The project will utilize equipment from two vendors: Aerohive Networks, and Emerson/Rosemount.

Aerohive has kindly volunteered supplying, on a demonstration basis, APs and antennas required to effect the wireless link. Emerson/Rosemount has also kindly volunteered to provide WiHART interfaces and gateways to allow wireless interface from existing instruments to the wireless network. Both firms have committed to providing technical support if needed. These goods and services will not require any funding from SWPCA. Minor installation, such as mounting the APs on the OCS tower and on the Ops building wall, can be done by SWPCA personnel; however, should this become an issue, installation by outside talent will be arranged.

Aerohive

The wireless link between the OCS and Ops building will be achieved by a point-to-point wireless link between two AP 170 dual band outdoor access points. The APs will communicate locally, that is, with mobile and fixed client devices on the 2.4 GHz ISM (Industrial, Scientific, Medical) band. Each AP will transmit on a different non-overlapping channel and frequency to avoid co- or adjacent channel interference. This band will be the primary method of communication with the instrumentation WiHART interface, telephony devices, the internet or video access at tablets, smartphones and PCs. This communication will be seamless, and will allow uninterrupted voice or data transmission within the coverage areas shown.

Communication between the access points for delivery of data to the terminal in the control room will be accomplished using the 5 GHz UNII (Unlicensed National Information Infrastructure) Band on the appropriate channels. This point-to-point communication will act in parallel to the existing wired network and perform the same function regarding process data delivery; this link will be capable of delivering wireless multimedia (voice, video) to mobile devices within the coverage area, which the wired network is not capable of providing.

Within the control room, an AP 121 indoor dual band access point will communicate with the exterior mounted AP170 to avoid the necessity of penetrating the building wall. At this range (approximately 3-6 feet) reliable communication and signal strength are not a concern, even though the exterior wall is brick construction. The AP 121 will be interfaced to a local wired network to a dedicated PC, physically isolated from the existing plant network. This will be done for the duration of testing in order to provide side by side comparison of process data from independent sources. Final implementation will integrate the wireless network into the wired distribution system, with appropriate segregation (VLANs) and security measures implemented.

Emerson/Rosemount

Emerson/Rosemount (E-R) will provide wireless interface devices to effect data acquisition sufficient to support the collection of appropriate process data during testing. E-R will will implement an open data collection system based upon the HART standard (Highway Addressable Remote Transducer). HART is a half duplex communication technology that allows operators to monitor all aspects of a compatible device. Existing field instrumentation is E-R branded and HART compatible.

E-R will provide local interface at the instrument using a THUM (The HART Update Module) wireless transducer which is a simple parallel connection across the existing wired interface. The standard control signal is based upon a 4 – 20 ma analog signal; this will be sent to a local wireless gateway, provided by E-R, which will process the signals and transmit the data to the local AP (AP 170). HART data is encapsulated within the wireless format and subsequently transmitted to the Ops AP on the 5 GHz channel(s). Using E-R utilities, process data is displayed on a customizable local web page with a fully featured graphical user interface (GUI). This interface will be installed on a standalone PC located in the control room and will not have any physical connection to the plant network. All test data will be obtained from this PC and will be used to compare to data obtained by the existing SCADA system
It is anticipated that basic process parameters will be monitored to provide a complete picture of process operation. Targeted process variables are: pH, ORP, sump level, Tower DP, and scrubbant recirculation flow, all of which are variable analog values. Fixed, or point data sources, such as sump level high, and emergency safety shower activation will also be monitored and transmitted to the control room.

Telephony

Another benefit of this technology is the ability to effect seamless mobile communication utilizing low cost "convergence" smartphones. This capability will allow operators to use one device to communicate amongst themselves, between an operator and supervisor, or between an operator and vendor; this communication can be done utilizing the WiFi system or the cellular carrier, depending on permissions and configuration. This benefit will eliminate the need for the current and costly mobile telephone services employed by the plant while affording reliable plant-wide voice communication. When out of Wifi range (Wifi can be obtained from many off-site access points and hotspots), the telephones would function as a conventional cellular telephone if required, utilizing the preferred carrier. When the operator returns to within the range of the plant wireless network, the communication will "off-load" to the plant network seamlessly.

The telephones used for this test have not been determined at this time.

Video Delivery

Another ancillary benefit of a plant-wide wireless network would be the ability to deliver multimedia to any covered area. This will afford the operator the ability to access specific and relevant equipment data at the site of the equipment using the internet, or by accessing a dedicated file server containing equipment operation, repair or maintenance data. The operator could also transmit photos or video directly to a vendor, while simultaneously communicating with the vendor in real time, again, at the site of the equipment. This capability will improve efficiency and has the possibility of drastically reducing the lost time associated with having to leave the jobsite, search paper files (or a terminal located in another area) and eliminate lost time resulting form data not being available locally.

Video can be delivered to any readily available smartphone, tablet, or PC that supports wireless networking.

Execution

Upon review and approval by the SWPCA Board, it is anticipated that installation and startup could commence during the first week of April 2014, and be fully operational within two weeks. The purpose of this testing is to prove the viability of a wireless process monitoring system; a testing regimen follow this section.

Security

Wireless security has greatly improved since the inception of wireless networking in 1997. Unlike a wired network, where an intruder needs to physically attach to the network in order to intercept data, wireless data can be acquired by anyone with a wireless enabled device and appropriate software tools.

Early security methods were easily compromised. Wired Equivalent Privacy (WEP) was quickly compromised and has since been deprecated. New security algorithms were put into place by IEEE 802.11i, an amendment to the 802.11 standard. All Wifi Certified equipment complies with this standard. This standard describes a method of encryption called Counter Mode with Cipher Block Chaining, Message Authentication Protocol/ Advanced Encryption Standard (CCMP/AES). The Advanced encryption Standard is defined in the Federal Information Processing standards publication 197 (FIPS-197). This mechanism is the basis for the WPA2 (Wifi Protected Access-2) security method.

WPA2 has two iterations; WPA2-Personal, and WPA2-Enterprise. WPA2-Personal, also known as WPA2-PSK, for Pre-Shared Key, uses a secret passphrase to mutually authenticate clients and access points. WPA2-Enterprise uses a method where secured and unsecured ports are use to mutually authenticate a client and access point using a database containing data about authorized clients.

During the POC phase of this project, a variation of WPA2-PSK will be used. Aerohive Networks offers a method of authentication known as Private PSK, or PPSK. This method of assigning passphrases allows each client device to have a unique passphrase as opposed to standard WPA2-PSK, which uses a single passphrase for all clients wishing to access the network. PPSK allows an administrator to revoke credentials for a single client rather than having to change a single password for all clients, which is difficult and time consuming.

The network name (SSID) will not be broadcast; this will simply “cloak” the network from casual observers who may be within the range of the access point. The opportunity for a casual or transient client to access the network is greatly reduced by this simple step.

Given the robust nature of modern wireless security, it is unlikely that a “hacker” would be able to illegally access the process network. The AES encryption method is extremely secure, and beyond the capability of all but the most skilled engineers to crack. Additionally, the network is designed to broadcast within the fence line of the plant, greatly reducing the opportunity for off-site interception. Finally, only process data and non-critical multimedia will be transmitted over the wireless network – no control of any process equipment will be attempted during this phase of deployment. In other words, there will be no opportunity for an intruder to take control of any process and cause damage or process upset.

Testing Methodology

In order to properly evaluate the reliability, security and overall performance of the wireless link, three areas of the system will be tested and data will be collected in order to provide side-by-side comparison with the existing SCADA system.

Reliability: Reliability refers to the ability of the network to deliver data in a consistent fashion, without error, and without loss of connectivity. Mechanisms provided by both participating vendors will allow continuous auditing of the wireless link, data throughput, bit error rates, and accuracy. The effects of normal EMI (electromagnetic interference) will be assessed under controlled conditions.

Security: Attempts will be made to compromise the wireless link from various locations within the link. Attempts at penetration testing will be made using readily available methods and specialized technicians. It is anticipated that these attempts will be unsuccessful.

Overall Performance: Data, voice and video traffic will be monitored in order to assess the effects of each upon the other. Latency will be measured and quantified. Coverage will be surveyed and confirmed.

Specific testing protocols are beyond the scope of this proposal; however, a separate document detailing testing methods will be developed and will be made available upon request.

Cost Analysis

Wired vs. Wired Networks

As an example of the cost savings that can be realized by implementation of this technology, a cost analysis of a 330” data link is presented below. This is approximately the distance of the test link and coincidentally, is the maximum length allowed for a conventional wired (Ethernet) network segment. Assumptions are that power is available at network endpoints and no adverse site conditions are encountered.

Cost estimate for buried cable between the Operations Building and the OCS:

Excavation of 140 yds. :$6500.00
Saw Cut 300” pavement : $3000.00
Stone base: $1000.00
Backfill: $4500.00
Patching: $3500.00
Conduit and cable: $500.00
Remote router and accessories: $600.00
Electricians: 5 man-days @ $1120.00/day: $5600.00

Total: **$ 25,200.00*** **(**Does not include Design services, appurtenances, management and IT Configuration)

Wired link exposed (simple conduit run):
Conduit and cable: $500.00
Appurtenances: $300.00
Remote router and accessories: $600.00
Electricians: 5 man-days @ $1120.00/day: $5600.00

Total: **$7000.00***
* Does not include Design services, appurtenances, management and IT Configuration

Wireless Link:

Design/Site Surveys: $2500.00
Access Points: 2 @ $1000.00: $2000.00
Labor: $1120.00
IT Configuration: $1200.00

Total: **$6820.00**

NOTE: There is no distance restriction, and network expansion simply requires an additional AP.
As can be seen from the above estimates, a significant cost savings, particularly in labor and maintenance, can be realized by utilizing wireless technology.

Total Cost of Ownership (TCO) is very low for a wireless network. A basic model for the TCO of WLANs is :

TCO= cost of equipment + cost of installation + cost of maintenance/upgrade

Given that the cost of wireless equipment is comparable, if not slightly more costly than wired routers, the two major variables in determining TCO are installation cost and maintenance. Equipment and installation costs are detailed in the examples above; long term maintenance is discussed below.

Another cost factor to be considered is Return On Investment (ROI). Multiple studies have found that payback is within 12 months, if not sooner. The savings in avoiding a wired network installation combined with the benefits of efficiency and productivity increases present an immediate offset, if not an immediate ROI. A paper by the Wireless LAN Association, describing TCO and ROI is attached to this proposal for reference.

Predicted maintenance, repair and upgrade costs of existing wiring

While modern cable and conduit systems have an predicted design life approaching twenty years, factors such as installation issues, site conditions, and material failures have greatly reduced the average life span of a cable and conduit system. It should be recognized that indoor and outdoor installations are exposed to completely different environments; our discussion will concern outdoor installations for the purposes of this proposal.

There are two types of outdoor installations: exposed and buried (underground). In a buried installation, failure can occur because of several factors. The most common mode of failure is the "backhoe syndrome"; this failure occurs when a backhoe or other equipment inadvertently tears up an unknown conduit. This is followed closely by deterioration of the conduit or cable from the infiltration of moisture into the conduit. While this is mitigated somewhat by the use of plastic conduit instead of metal, plastic conduit will also deteriorate from physical stress and age faster than metal conduit. When either type of conduit is compromised, cable will rapidly deteriorate, and fail prematurely. Improper installation, such as improper bedding or marking, will also contribute to the premature failure of the conduit system.

Exposed installations are directly affected by environmental factors. Weather, sunlight and corrosive gases all conspire to deteriorate conduit and wiring. Plastic conduit, while advertised as UV stabilized, will steadily deteriorate from direct exposure to sunlight and become brittle. Metal conduit will quickly corrode in the presence of H2S or SO2, common gases in a wastewater processing environment. While conduit and appurtenances (junction boxes, pull boxes) are rated for corrosive environments, infiltration of gas and moisture into the conduit system is very common in aging systems and quickly compromises the cables installed in the system.

The costs associated with maintenance, replacement or expansion of a wired network vary according to the method of installation and parallel the costs shown in the analysis in the previous section. The bottom line determining the magnitude of these costs is the scope of the installed physical plant: the cost varies proportionally with the size of the system – these costs are minimal for a wireless network. With a physical system, there are real installation and replacement costs; wireless systems do not rely upon a physical medium, hence, that cost is removed. Upgrade or replacement of wireless components

is a small fraction of the initial installation cost. Long term maintenance costs are practically non-existent. As technology progresses, and as has been shown historically, the cost of technology steadily decreases; the cost of labor increases over time.

To summarize, conventional wired networks are two to three times more expensive to install, maintain or expand as an equivalent wireless network; wired networks are vulnerable to physical deterioration over time, requiring eventual replacement in kind; subsequent replacement of wired networks is costly and time consuming, while wireless technology trends to lower cost over time. Expanding wired networks are also costly and time consuming, while expanding wireless networks usually only requires additional access points and a minimum of labor and time.

Plant-Wide Deployment (Phase 2)

Preliminary design study

A preliminary design study has been performed which shows that the entire process area located outside of buildings can easily be provided wireless coverage using six AP170 APs. The full deployment will require the use of directional antennas to avoid interference with businesses bordering the plant fence line. The coverage map without directional antennas is shown in the exhibits.

Cost estimate (Budgetary)

Aerohive (Complete plant-wide coverage)

Description	**QTY**	**Price**
AP-121 Indoor AP	1	$430.00
AP-170 Outdoor AP	6	$6000.00
Hivemanager VA	1	$1320.00
20W POE Injectors	6	$1600.00
5GHz directional antenna	6	$3000.00
5 year 24X7 Support	1	$2000.00
Hivemanager License	1	$420.00
Total:		**$14,770.00**

Rosemount (Per Area/point)

Description	**QTY**	**Price**	
WiHART Gateway	1	$2,081.00	One gateway per process area
Analog WiHART (THUM)	1	$846.00	One THUM per analog point
Digital WiHART	1	$2071.00	Dual channel input module
Software	1	Included with gateway	
Support	1	TBD	

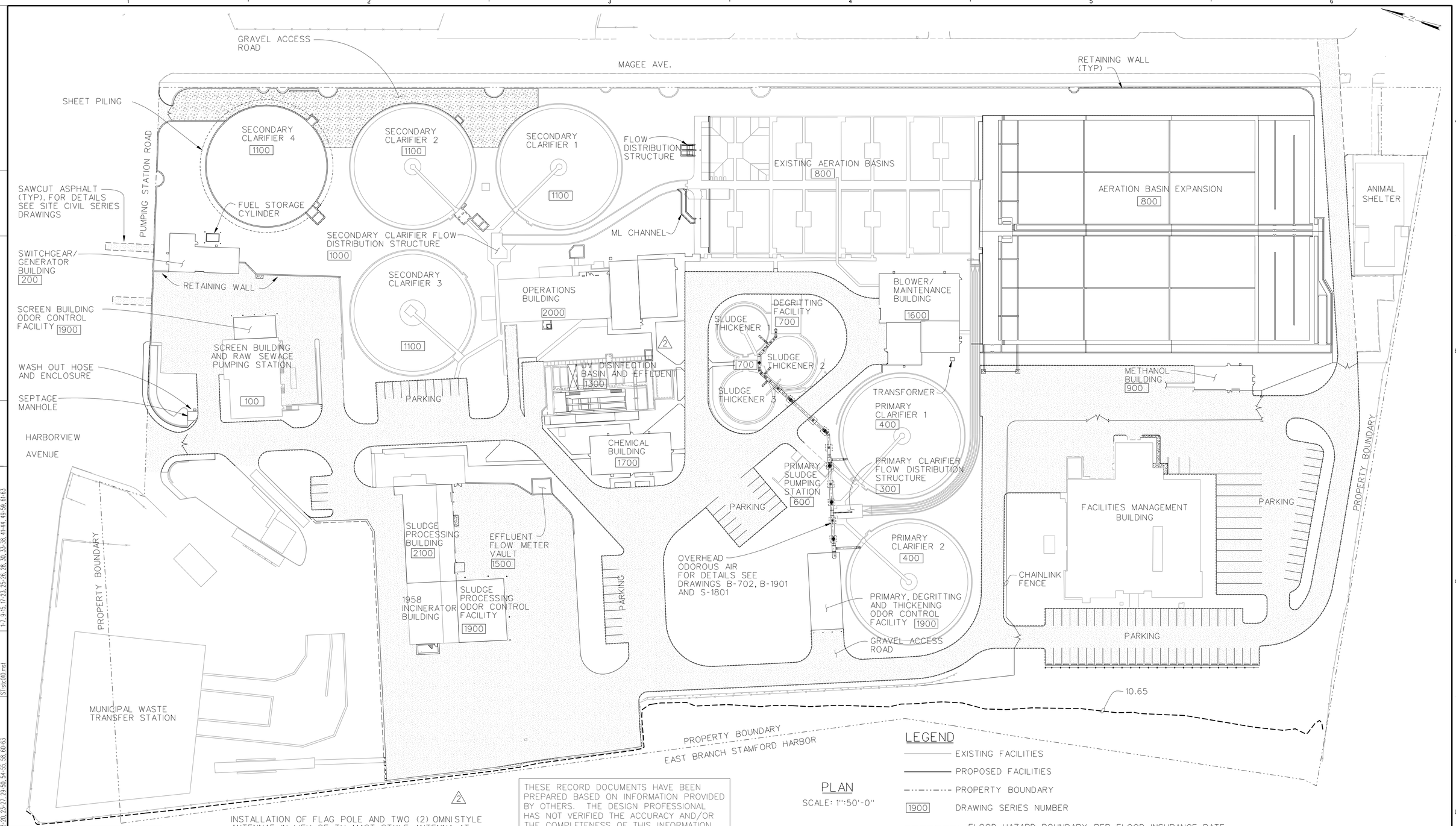
Labor*

Description	QTY	Price	
Installation of one module	1	$75.00	Based on one man-day at $1200.00/day
Installation of APs	1	$150.00	“ “
Software configuration	2	$2400.00	

* Does not include Design, SCADA integration, management, or external IT talent

Exhibits

- **Plant Site Plan**
- **OCS P&I Drawing**
- **RLOS Calculation**
- **Predictive survey, 2.4GHz Phase 1**
- **Predictive Survey, 5GHz Phase 1**
- **Predictive survey, 2.4GHz, Phase 2**
- **Predictive Survey, 5GHz Phase 2**
- **WLANA ROI Analysis**



PLAN

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LEGEND

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- PROPOSED FACILITIES
- PROPERTY BOUNDARY
- 1900 DRAWING SERIES NUMBER
- FLOOD HAZARD BOUNDARY PER FLOOD INSURANCE RATE MAP 090015-0007D IN CITY OF STAMFORD DATUM. NO STORM BARRIER 100 YEAR FLOOD ELEVATION=10.65 FT AS PER THE FEDERAL EMERGENCY MANAGEMENT AGENCY.

2

INSTALLATION OF FLAG POLE AND TWO (2) OMNI STYLE ANTENNAE IN LIEU OF TV MAST STYLE ANTENNA AT CUMMING POINT LOCATION. THE NEGOTIATED COSTS ASSOCIATED WITH THIS WORK ARE INCLUDED IN THIS CHANGE ORDER.

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DSGN	R.FLINDALL
DR	C.ANTHONY
CHK	M.OSBORNE
APVD	K.CLANCY

NO.	DATE	REVISION	BY	APVD
4	4/24/06	RECORD DRAWING		
3	9/09/05	CO PL-437 PROVIDE TEMP. BUILDING ID NUMBERS ON ALL		
2	9/08/05	CO PL-432		
1	6/28/05	CO PL-403		

VERIFY SCALE
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STAMFORD
WATER POLLUTION CONTROL FACILITY
UPGRADE AND EXPANSION

GENERAL
SITE PLAN

SHEET 0
DWG NO. G-19
DATE MAY 2000
PROJ NO. 148894.A1

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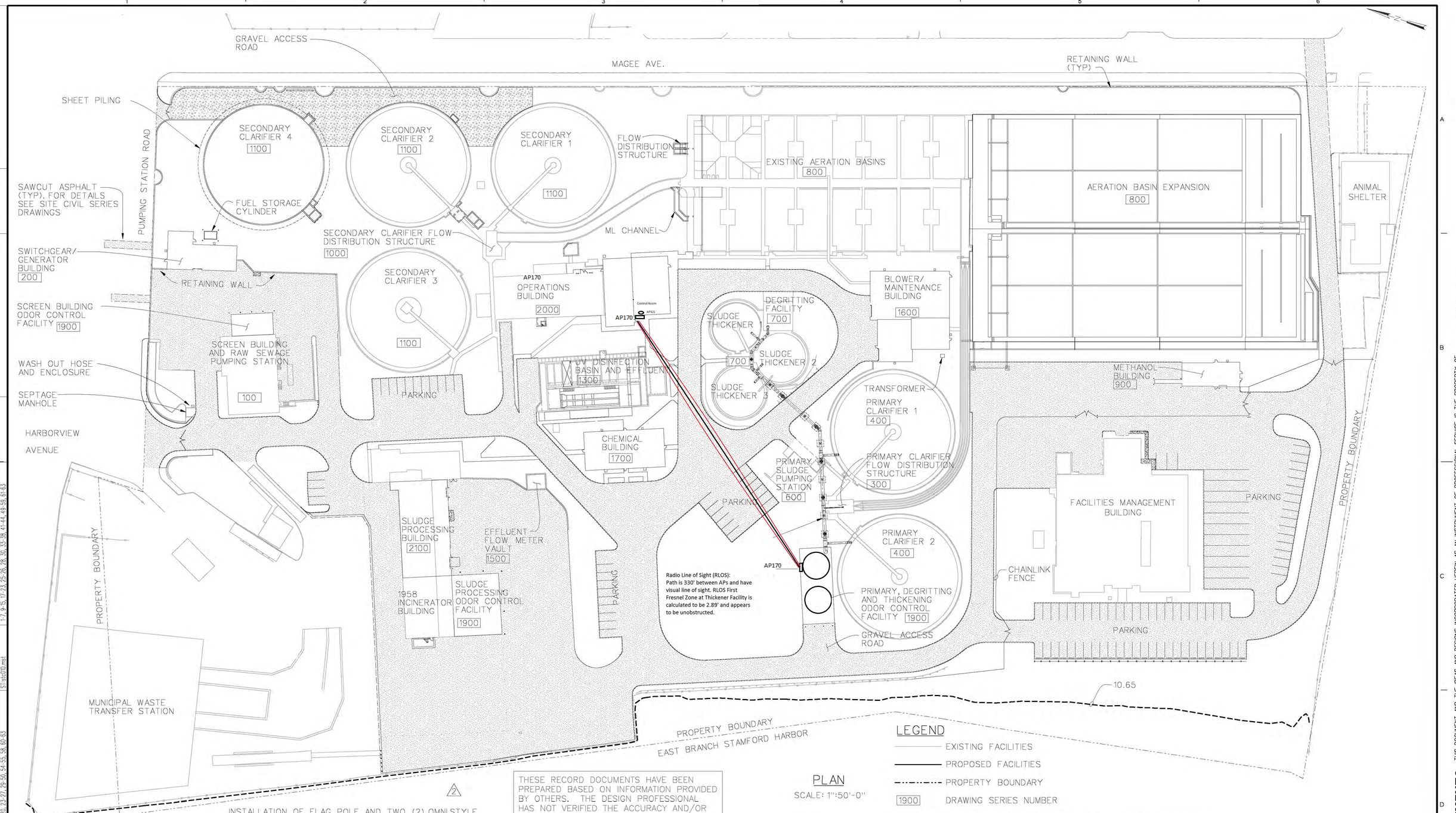

LEGEND

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PLAN

SCALE: 1":50'-0"

2

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APVD	K.CLANCY

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4	4/24/06	RECORD DRAWING		
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STAMFORD
WATER POLLUTION CONTROL FACILITY
UPGRADE AND EXPANSION

GENERAL
SITE PLAN

SHEET 0
DWG NO. G-19
DATE MAY 2000
PROJ NO. 148894.A1

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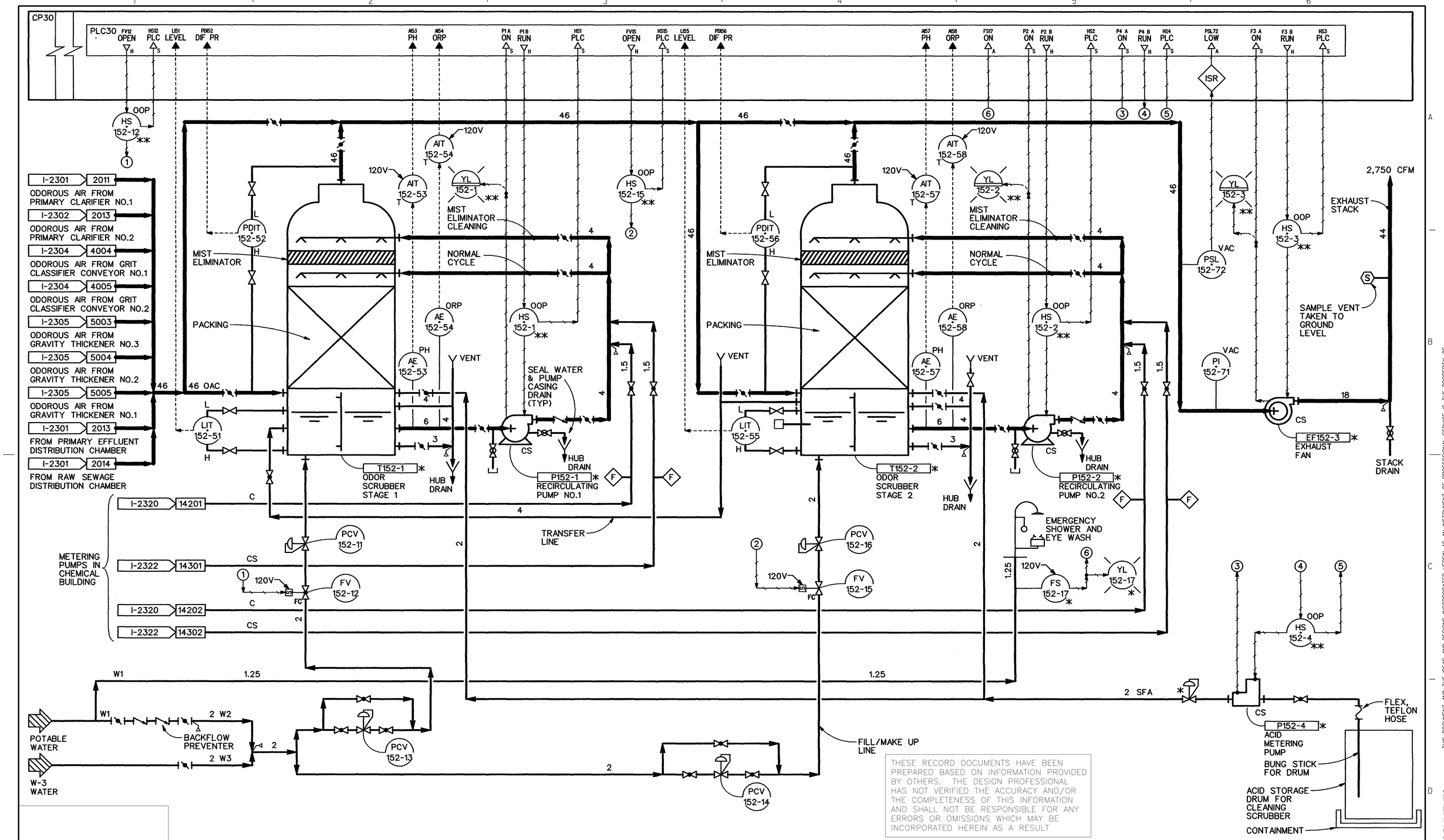

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DSGN E FONTANEZ					
DR S CHEUNG					
CHK T RIDGIK					
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	NO.	DATE	REVISION	BY	APVD

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STAMFORDWPCA

STAMFORD
WATER POLLUTION CONTROL FACILITY
UPGRADE AND EXPANSION

INSTRUMENTATION
P&ID- PRIMARY, DEGRITTING AND THICKENING ODOR CONTROL FACILITY

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DATE MAY 2000
PROJ NO. 148894.A1

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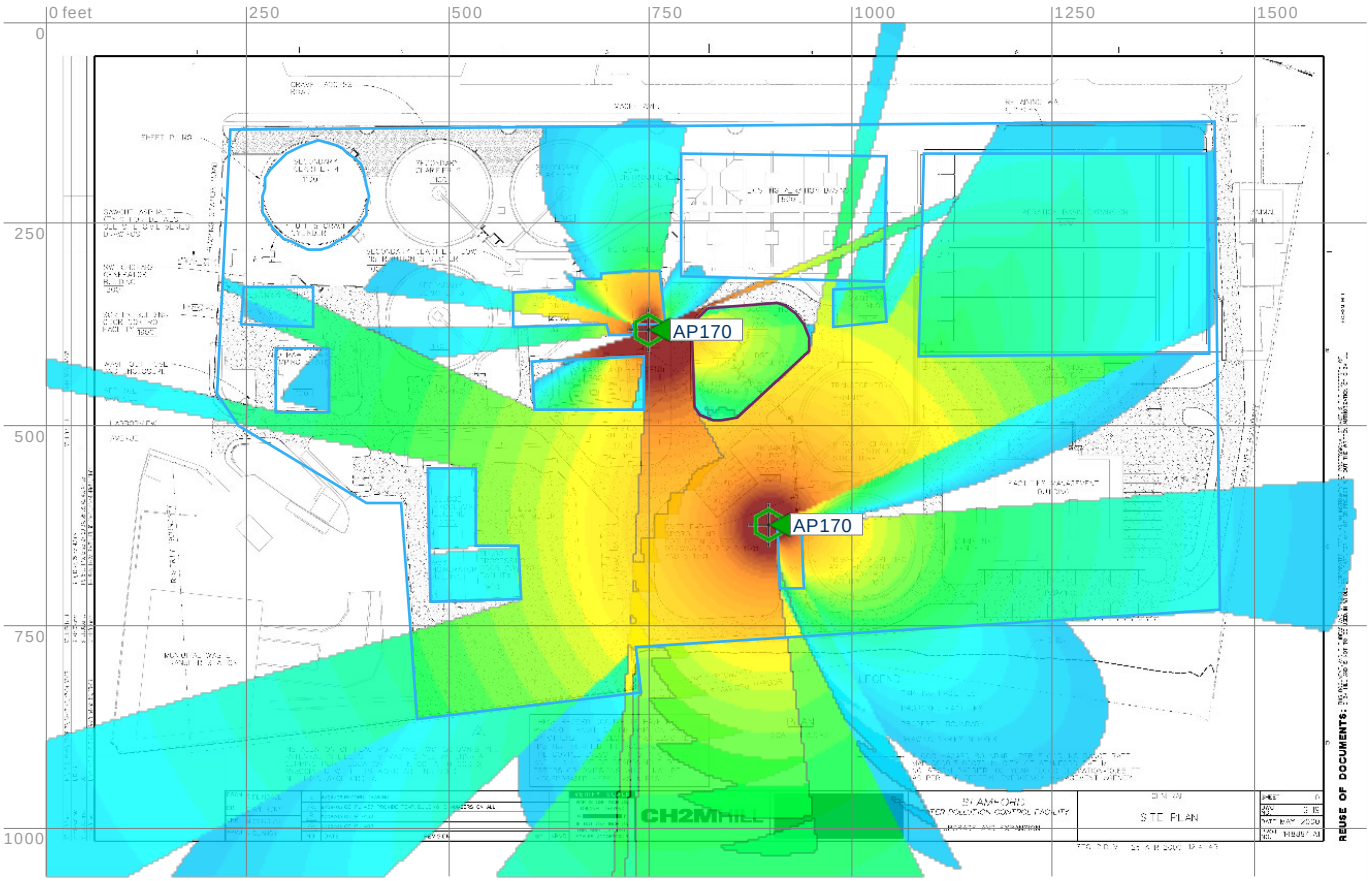
1. SWPCA Plan

Summary

Number of Devices assigned to SWPCA Plan

- 2 APs

Devices on SWPCA Plan (2.4 GHz, RSSI View: -35 -70dBm)



Device Details

Name	Model	Type	2.4 GHz		5 GHz		Description
			Channel	Power	Channel	Power	
AP170	AP170	802.11n	Auto(1)	20 dBm	Auto(36)	20 dBm	
AP170	AP170	802.11n	Auto(6)	15 dBm	Auto(40)	15 dBm	

Device Total For SWPCA Plan

Model	Part number	Total
AP170	AH-AP-170-N-FCC	2

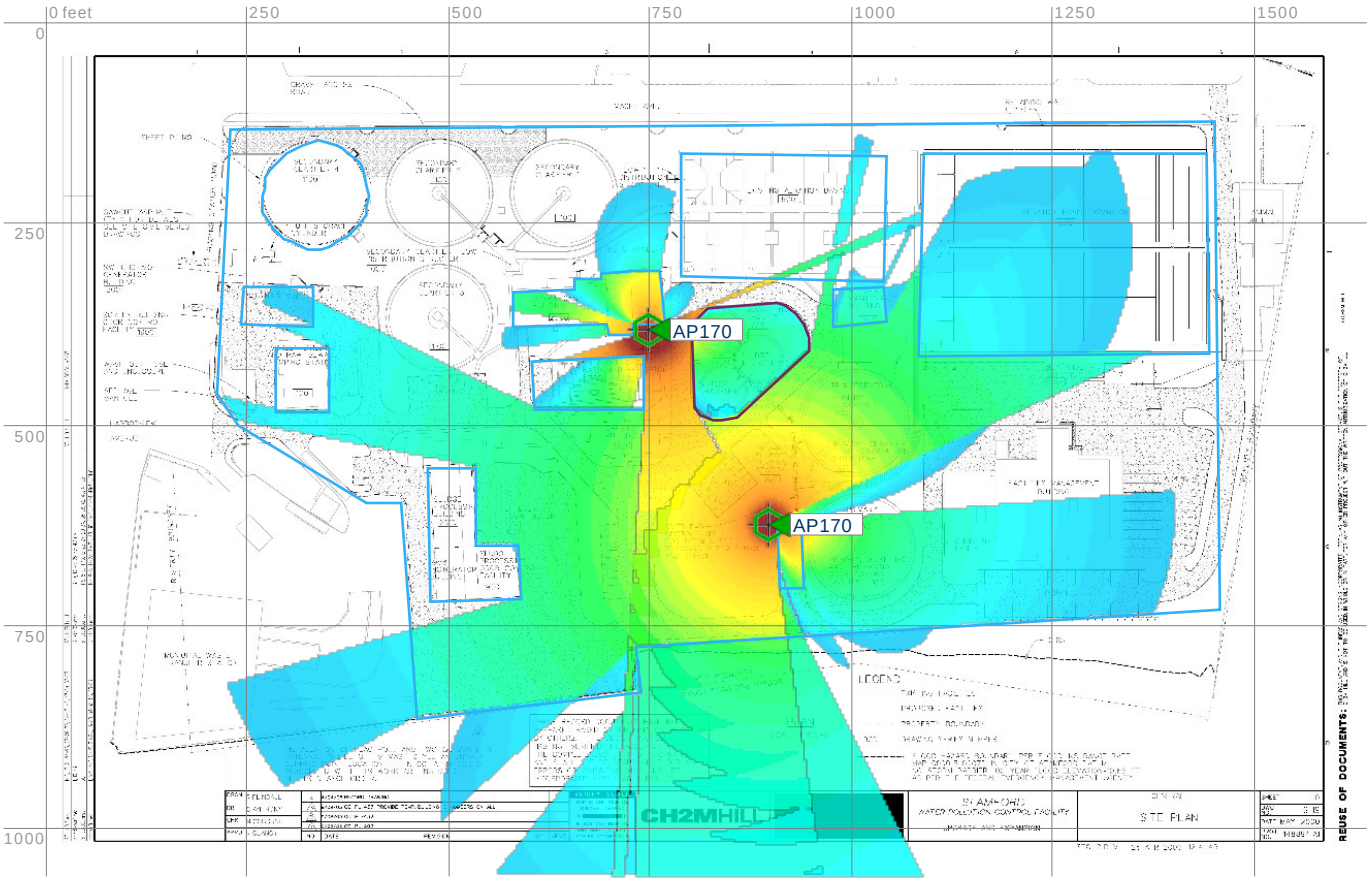
1. SWPCA Plan

Summary

Number of Devices assigned to SWPCA Plan

- 2 APs

Devices on SWPCA Plan (5 GHz, RSSI View: -35 -70dBm)



Device Details

Name	Model	Type	2.4 GHz		5 GHz		Description
			Channel	Power	Channel	Power	
AP170	AP170	802.11n	Auto(1)	20 dBm	Auto(36)	20 dBm	
AP170	AP170	802.11n	Auto(6)	15 dBm	Auto(40)	15 dBm	

Device Total For SWPCA Plan

Model	Part number	Total
AP170	AH-AP-170-N-FCC	2

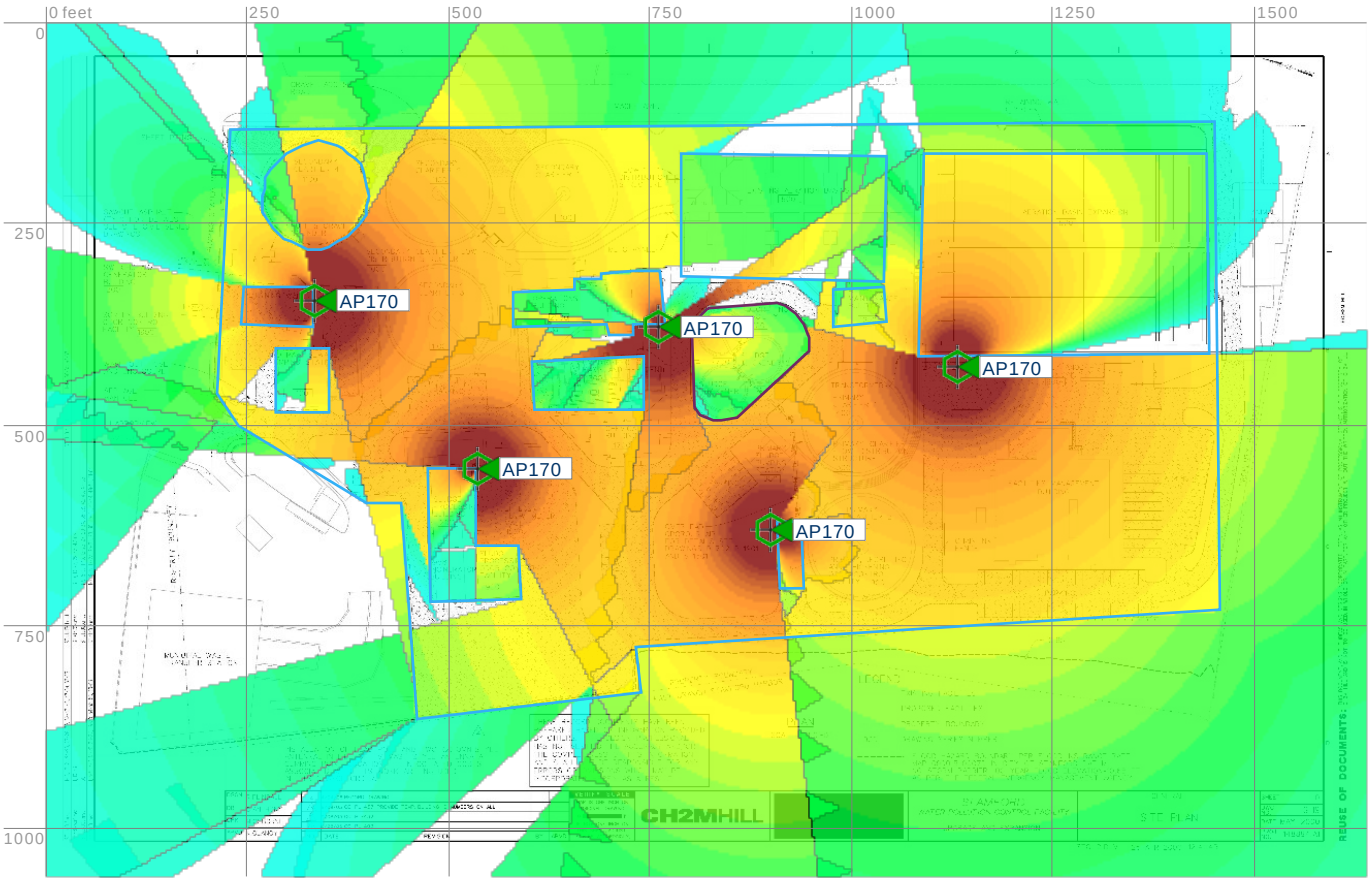
1. SWPCA Plan

Summary

Number of Devices assigned to SWPCA Plan

- 5 APs

Devices on SWPCA Plan (2.4 GHz, RSSI View: -35 -65dBm)



Device Details

Name	Model	Type	2.4 GHz		5 GHz		Description
			Channel	Power	Channel	Power	
AP170	AP170	802.11n	Auto(6)	20 dBm	Auto(149)	18 dBm	
AP170	AP170	802.11n	Auto(11)	18 dBm	Auto(48)	15 dBm	
AP170	AP170	802.11n	Auto(1)	20 dBm	Auto(36)	20 dBm	
AP170	AP170	802.11n	Auto(11)	20 dBm	Auto(44)	20 dBm	
AP170	AP170	802.11n	Auto(6)	18 dBm	Auto(40)	15 dBm	

Device Total For SWPCA Plan

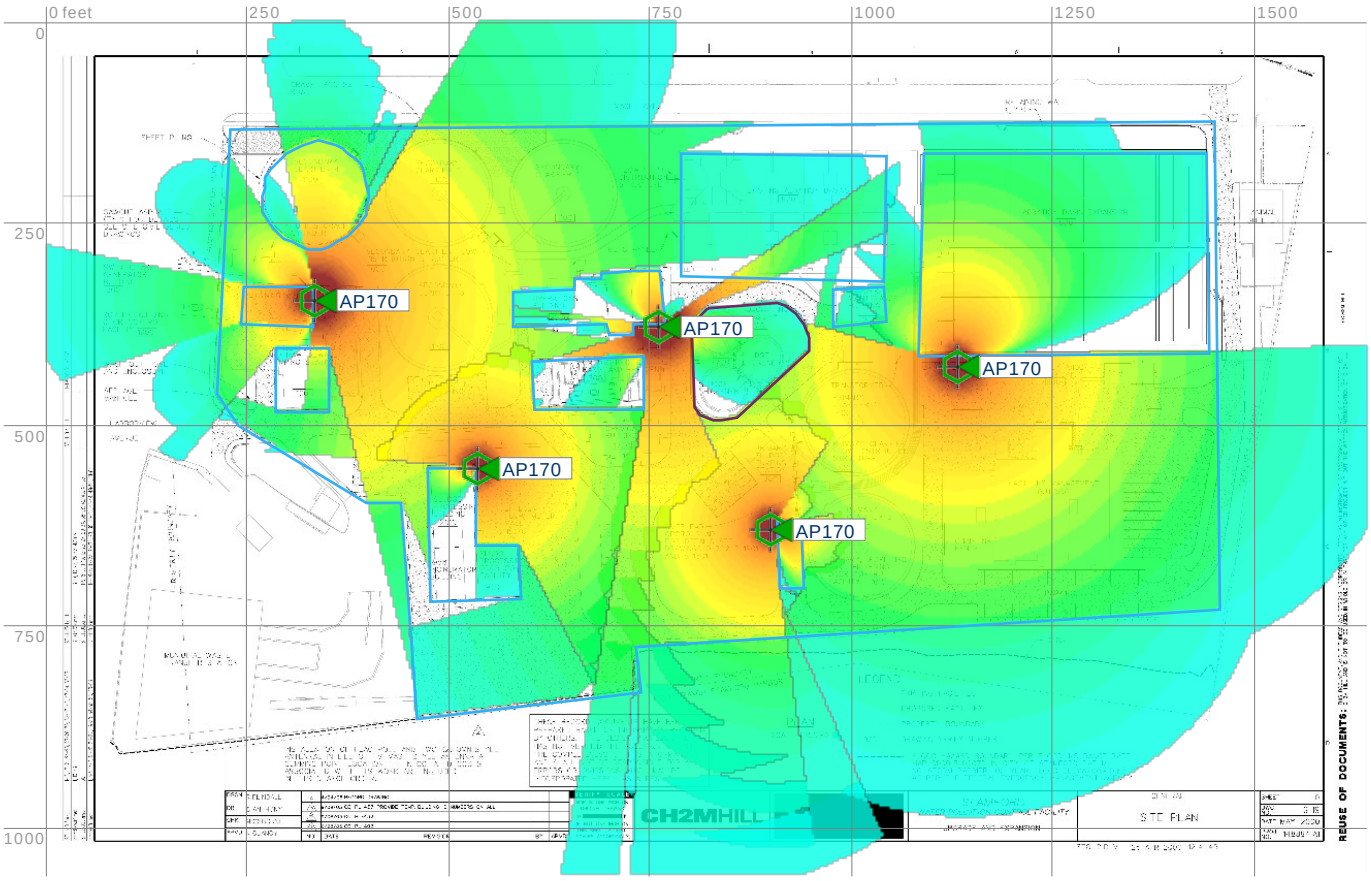
1. SWPCA Plan

Summary

Number of Devices assigned to SWPCA Plan

- 5 APs

Devices on SWPCA Plan (5 GHz, RSSI View: -35 -65dBm)



Device Details

Name	Model	Type	2.4 GHz		5 GHz		Description
			Channel	Power	Channel	Power	
AP170	AP170	802.11n	Auto(11)	18 dBm	Auto(48)	15 dBm	
AP170	AP170	802.11n	Auto(11)	20 dBm	Auto(44)	20 dBm	
AP170	AP170	802.11n	Auto(6)	18 dBm	Auto(40)	15 dBm	
AP170	AP170	802.11n	Auto(6)	20 dBm	Auto(149)	18 dBm	
AP170	AP170	802.11n	Auto(1)	20 dBm	Auto(36)	20 dBm	

Device Total For SWPCA Plan

Wireless LAN ROI

Outline

- Executive Summary
- Major Findings
- Overview by Industry
- Scope of Study
- About WLANA

EXECUTIVE SUMMARY

A fundamental challenge facing information technology (IT) decision makers is identifying and implementing architectures, technologies, and processes that reduce the total cost of ownership (TCO) of corporate networks - one way is the wireless LAN. Based on the results of this study, we believe that if companies understand the true costs and economic benefits of wireless LAN solutions they will generate quicker return on investments.

Currently the wireless LAN is not a replacement for the wired infrastructure, but it is a significant complement to what currently exists. Schools, manufacturing companies, hospitals, and offices purchase these wireless LAN systems for two predominant reasons: they are seeking an increase in user productivity and IT team productivity.

Companies that integrate or upgrade with these systems will stretch IT resources further and be able to reap economic and business benefits sooner than companies taking a wait-and-see approach - especially now that a solid standard exists for wireless local area networking. As a result of this standard and higher performing or higher speed systems, tomorrow's enterprises will likely have a mix of wireless and wired LAN systems.

Interviews for this study were conducted with wireless LAN users in the following industries:

- Education (In-building K-12 and University/College connectivity)
- Healthcare (Point of Care)
- Manufacturing (Production/Distribution/Maintenance/Shipping/Receiving)
- Retail (Point of Sale)
- Financial/Office -Automation (Stock Exchange, Banking, Consulting)

MAJOR FINDINGS

This Wireless LAN Cost of Ownership report is focused on the results of a detailed end-user survey to identify cost of ownership and tangible and intangible gains in using wireless LAN technology. It is apparent that the technology is taking its place as a viable alternative and/or complement to wired LANs and for new strategic applications.

- 89% of the companies experienced a successful implementation.
- 92% of respondents interviewed believe there is a definite economic and business benefit after installation.
- 92% of respondents reported that they will continue to deploy wireless technology in their network through 2000 because of the benefits experienced by end users and/or IT staff.
- Payback was less than one year, across all industries surveyed.

The survey combines both telephone and written responses from 34 organizations. (See Scope of Study for more details). The survey consisted of both open-ended and multiple-choice questions. It was designed to provide the Wireless LAN Alliance (WLANA) with as broad a response base as possible regarding specific costs, attitudes and experiences with their overall wireless LAN ownership. All of the respondents involved subsequently completed a more extensive, follow-up written survey. Companies, schools, and medical

facilities were assured anonymity. The analysis that follows identifies only by industry category and reports the data in the mean.

Some important findings are listed below:

REAL-TIME ACCESS TO INFORMATION

One of the consistent findings of this study was how end-users benefited from real-time information. In fact, 97% of respondents said they either strongly agree or agree that the wireless LAN contributed to the speed in which they completed a task requiring real-time or near real-time access to information.

COST OF OWNERSHIP

The study compared the costs of 34 wireless LAN installations. Costs for applications, outsourcing and network management are critical factors that need to be considered before the wireless LAN can either supplement the wired LAN or replace it as a wired LAN alternative. These savings are substantial from the viewpoint of manufacturer, retailers, hospitals, schools, and financial organizations. A wireless LAN enables them to provide better quality goods, at reduced costs, in a significantly less time.

On average, the total cost per user was found to be $4550 for a wireless LAN solution. This includes the costs identified below (Note that the WLAN Hardware/End User Devices category includes the computing platform used, which was generally a handheld or laptop computer.) Wireless LAN infrastructure and end user devices account for the highest percentage cost out of this total. The percentages for wireless LAN expenses, by category, were as follows:

- WLANA Hardware/End User Devices: 50%
- Monthly expenses: 1%%
- Management expenses: 16%
- Application development expenses: 16%
- Outsourcing: 16%
- Downtime: 1%

ECONOMIC BENEFITS

With large investments in wireless LAN technology at approximately $300,000 to $4.2 million dollars per year, we clearly realize and sympathize with the managers that have been struggling to quantify the benefits that derive from wireless LANs. Organizations implementing an average of 300 client cards reaped annual savings of up to $4.9 million, which translated into per user savings of $15,989. As the wireless LAN solution is implemented on a large scale, these savings will eventually trickle down to the consumer.

PAYBACK

Across all industries, the wireless LAN paid for itself within 12 months time. This is with all economic benefits considered. The payback period of this investment is the period of time required for the cumulative cash flows due to increased productivity, organizational efficiency and extra revenue/profit gain to equal the initial investment.

	Retail	Manufacturing	Health-care	Office Automation	Education
Benefits per company(millions $)	5.6	2.2	.94	2.5	.5
Costs per company(millions $)	4.2	1.3	.90	1.3	.3
Payback(# of months)	9.7	7.2	11.4	6.3	7.1

OVERVIEW BY INDUSTRY

EDUCATION

With Wireless LANs in place, respondents cited a more efficient use of space, and more in-class productivity. At most education sites, the access point was located directly in the wiring closet or in a lab. With a wireless LAN, only the access point needs a wired network connection. Classroom or lab computers were connected to the access point via radio frequency.

K-12 schools needed a way to save money on network and computer costs. The Education Rate (E-rate) with 10% to 90% savings was available, but they needed even more ways beyond this to save. With wireless LANs they were able to save money by buying fewer computers. The solutions ranged from using cart-mounted computers wirelessly hooked to the wireless LAN. The carts could be moved to the classrooms where they were needed. The schools saved money by buying fewer computers as well as wiring to a central hub.

Wireless LANs turned out to be very inexpensive on a per-student basis. Wireless infrastructure costs for the educational sector averaged $2308. In this study 1345 students benefited from the wireless solution which in an average configuration included 25 access points and 112 computers equipped with wireless adapters. The savings can be attributed to the utilization of cart-mounted computers and fewer network drops as a result of the wireless LAN. With carts, fewer rooms would have been required to be networked and populated with computers.

Also, since many of the schools had a mandate to get students on the Internet to access more or better learning activities and since the wireless system served as a tool to make this happen, a very fast and easy installation was required. Wireless LANs met their needs as well. In this study students in the university setting demanded access to LAN resources from dormitories, classrooms, and throughout campus. Wireless LANs were being used to help students be more mobile and the schools to reduce network costs and connect remote locations to central buildings and servers. In the university environment providing a wired connection was extremely expensive, especially when it involved historical buildings - running cable through ceilings and walls was cost-intensive. Running wire through ceilings and walls in buildings at one site was going to potentially disturb asbestos insulation, forcing a removal process estimated to cost over $90,000.

HEALTHCARE

With fast-rising healthcare costs, reimbursement and ROI are key to the requirements of IT investments in the medical industry. Healthcare spending in the U.S. has grown from $280 billion in 1981 to more than $1.5 trillion in 1997 and currently accounts for about 14% of the total gross domestic product.

With healthcare costs increasing at a rate of about 5% per year, cost containment is an important issue. Hospitals are centralizing laboratories, reducing costs, and increasing their use of automated technology. The wireless LAN has shown to meet the technology and organizational needs of healthcare companies today by decreasing the length of hospital stay, speeding diagnostic and case analysis time turnaround, reducing hospital labor, procedural costs, documentation, and scheduling time.

MANUFACTURING/WAREHOUSE

Warehouse workers are increasingly demanding mobile scanners or pen-based computing tablets for inputting and accessing data in real-time. These devices are linked to mainframes or servers that usually have a software application running on them such as inventory collection, order fulfillment, and shipping/receiving applications. By connecting to inventory records and purchase orders, companies reduce the inefficiencies of transferring numbers through paper forms.

Wireless LANs connected to automated, handheld computers on manufacturing or factory floors are a viable alternative to wired LANs. Laying cable in these environments proved cost prohibitive, or not feasible because of the size of the warehouse. Also changes in assembly lines are frequent and many employees do not work in any fixed location for one straight month. In this study, we have seen that workers and management in the manufacturing environment need instantaneous access to accurate information so they can better track orders, production runs, and production quantities in real time.

PRODUCTION

Wireless LANs automated the production, maintenance, and troubleshooting (repair) process at production bays of a foundry, production lines of an automotive manufacturer, and the outside work area of an aircraft manufacturer. The use of production planning and control software combined with wireless LAN technology illustrates the positive effect of this specific IT on an organization. A typical medium-sized to large manufacturing firm must stock, control and ensure the availability of thousands of items (end products, parts, and raw material). Further, production of the parts and raw material must be coordinated to ensure that the firm meets order commitments and production plans. Using manufacturing software with automated inventory status reporting, order processing, production scheduling, and invoicing features, made it possible for companies to control complexity. But in this study, we found that having a wireless LAN connected to this software enabled operators to go beyond second-guessing the age of the information coming over the wire. It appeared in real-time or near real time. This combination of hardware and software reduced the control and coordination and associated costs.

RETAIL

The retail industry category in this study comprised a collection of segments from diverse businesses, such as restaurants, specialty stores, prepared food stores, and military stores that vary in the types of items they sell and the market size for the items. But, they all sought faster rates in getting customers through checkout and totaling orders, and faster receipt of goods, and taking inventory. In retail establishments considerable effort is taken to attract customers, and reduce long lines.

Wireless LANs also contributed to the good health of retail establishments. Wireless POS cash registers and bar code client devices provided access to store inventory and pricing information. Scanning had a high impact on productivity at checkout through improvements due to easier price changing, and price removal, price identification. For example, price changes can be recorded in a central database at the store rather than on each item.

The wireless LAN infrastructure provided critical decision-makers in retail with real-time information on the ordering, collection, distribution, and sale of goods. The wireless network offered them a higher initial purchase price, but reduced support costs and increased checkout productivity and flexibility.

FINANCIAL

The financial/office automation category in this study comprised a collection of segments with varying businesses, such as banking, stock trading, consulting, auditing, and the office areas of a technology firm. Office automation was a goal for the consulting, auditing, and technology firm. All of these firms face come under considerable competition. Keeping up with the competition as well as offering new services are paramount.

In almost every instance the cost conscious system manager chose not to standardize exclusively on this new technology. This is because doing so required a large investment in changing the nearby network infrastructure. Many system managers were attracted to the wireless LAN for its flexibility, easy installation and, in the case of the stock exchange participant, mobility.

In the case of banking, the wireless LAN enabled account representatives and tellers to provide better service to customers and has been used to support a plethora of new transaction processing services. The auditing and stock trading organizations were just as, if not more data-intensive environments, characterized by volumes of accounting, analysis, and statistical data. The auditing firm was concerned about the quality of business generated by auditors, as measured, for example by the level of engagements handled by the company. But all these companies must be able to predict risks and risk factors and facilitating group collaboration is critical for reaching that goal. In the financial area, the wireless LAN saved hundreds of hours because group collaboration was easier. Individuals within these organizations are increasingly turning to portable computers to communicate with the home office or master server for various functions. The auditor tied to the home office through a portable wireless LAN can serve a customer much more effectively than by dial-up lines, as can sales people and consultants working or collaborating in a conference room.

SCOPE OF STUDY

The cost of owning a wireless LAN consists of infrastructure and software costs, client device costs, monthly costs, power costs, downtime costs plus all of the related management and support costs. Identifying management costs is a complex task. Management costs can include network infrastructure planning, training, troubleshooting and repair, and hardware management.

There are various types of criteria used to determine the cost savings of wireless networking equipment. We looked at business benefits and economic benefits. The main way in classifying technology benefits is to analyze how it assists in measuring and monitoring them, with a perspective to controlling and maximizing any positive effects of the change. There are criteria for measuring the benefits on a new system or a system already in place with an upgrade.

The measuring techniques in this study varied slightly depending on the benefits sought and the application that used the wireless LAN. Wireless LAN total cost of ownership must be derived from across a range of applications. However, there is always the one constant, that there is a history dating back to a time before the system was implemented. Meaningful analysis of the effects of the change is undertaken here.

This study focuses on radio-frequency-based systems. These wireless RF LANs compliment wired LANs, providing installation flexibility in difficult cabling situations, and user mobility. The wireless technologies used to support data transmission over short distances in buildings and without physical connections include radio waves and infrared light. The radio frequency (RF) in-building wireless LAN products are designed around radio technology and protocols using spread spectrum modulation techniques (Direct Sequence or Frequency Hopping).

This study looks at the cost of ownership of in-building RF LAN products that operate within 100 to 3000 feet of an access point.

The study involved in-depth interviews with wireless LAN customers. **Note:** This study involved WLANA customers, as well as customers of several other wireless LAN vendors who are currently not in the WLANA organization.

The Cost of Ownership study encompassed a phone-administered interview. Tech Research asked participants about the costs and benefits of wireless LAN ownership and the difference it is making in end-user and IT staff work and within the organization.
Each participant was interviewed over the phone at his or her office. The interviews generally lasted between 40 and 60 minutes. The length and quality of answers coming

from the interview depended on the participant¼s experience/contact with the wireless LAN system and/or contact with people using the wireless LAN.

Respondents were knowledgeable individuals regarding the subject matter. The administrator probed for detailed information and/or clarified questions at times to maximize respondent understanding and yield complete answers for the study. The questionnaire contained no questions leading to one conclusion or another. The questioning allowed end-users to speak in their own words and reveal their thoughts surrounding the purchase process, ideas of ROI of the wireless LAN, costs and the benefits associated with wireless LANs.

After the phone interview answers were documented and faxed or mailed to the participant for confirmation. We told participants that by answering the phone interview/faxed/mailed questions about their experiences with wireless LANs that it will help in influencing the generation of a report on Cost of Ownership of Wireless LANs that will address the cost savings and benefits of wireless LANs. The faxed/mailed questionnaire was usually returned within 2 to 10 working days.

The faxed/mailed questionnaire was easy for participants to understand and mark up. In the case of 85% of the respondents the faxed questionnaire forced them to do research into their notes or invoices on the subject.

The WLANA organization provided a gift incentive for participation-in this case it was a Palm Pilot Organizer. After the interview process was over it was clear the incentive was not only the gift, but also the ability to see their costs and economic benefits written out for them, a tool they could use at a later date for cost justification of more equipment. Both provided incentives to participate, answer more questions and/or answer questions more thoroughly.

Because the sample size is small (n=34) the possibility that inadequate information and the probability of error is high. However because the feedback during the phone interviews and from faxed questionnaires were consistent in nature, they provided an adequate indication as to what general trends were. Due to data collection techniques at the personal interviews we were able to get higher quality data than anticipated.

Not every cost savings derived from using the wireless LAN was quantifiable for participants. They are real however, and no less important. Many of these are related to organizational efficiency and network availability.

Standard editing and coding procedures were utilized. Simple tabulations and cross tabulations were utilized to analyze the data.

We are grateful to all participants for their time. We value their participation and thank them for their cooperation. We hope this study will provide information that is useful to current and future wireless LAN technology adopters.

COO Survey Respondents

Our research was based on the experience of small, medium, and large enterprises in the Healthcare, Manufacturing/Warehouse, Retail, Education, and Financial/Office Automation industries. The results should be interpreted as reflecting viewpoints indicative of a part of the larger wireless LAN installed base. Our intention to deliver a broad cross-section of the representative industries with applications conducive to wireless LANs was generally successful, although not equal to the population represented. Survey findings should be interpreted accordingly. The breakdown of participants by industry was:

- Education: 23% (8)
- Healthcare: 23% (8)
- Manufacturing/Warehouse: 21% (7)

- Retail: 15% (5)
- Financial/Office Automation: 18% (6)

This study primarily features customers who have wireless LANs installed at one or more sites and had completed deployment or were still in the process of upgrading.

Source WLANA

The Wireless LAN Association (WLANA) is a non-profit industry trade association formed to increase awareness and encourage the adoption of wireless LANs products and technologies.

The Association maintains an educational web site at www.wlana.org with industry white papers, end-user case studies and links to related topics and member web sites.

Members

The Wireless LAN Association membership is comprised of 11 leading worldwide suppliers of wireless local area networking products and technologies.

- 3Com Corporation www.3com.com
- Cisco Aironet www.aironet.com
- Bay Networks www.netwave-wireless.com
- BreezeCom www.breezecom.com
- Cabletron Systems, Inc. www.cabletron.com/wireless
- Harris Semiconductor www.semi.harris.com
- Intermec Technologies, Inc. www.intermec.com
- Lucent Technologies www.wavelan.com
- Proxim, Inc. www.proxim.com
- Raytheon Wireless Solutions www.raylink.com
- Symbol Technologies www.symbol.com

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