

# Total-Flow Automatic Sampler for Pumping Station S-5A



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# Background

## ■ S-5A

- pumping station in the Palm Beach County
- located at the northern tip of the Water Conservation Area 1 (WCA1)

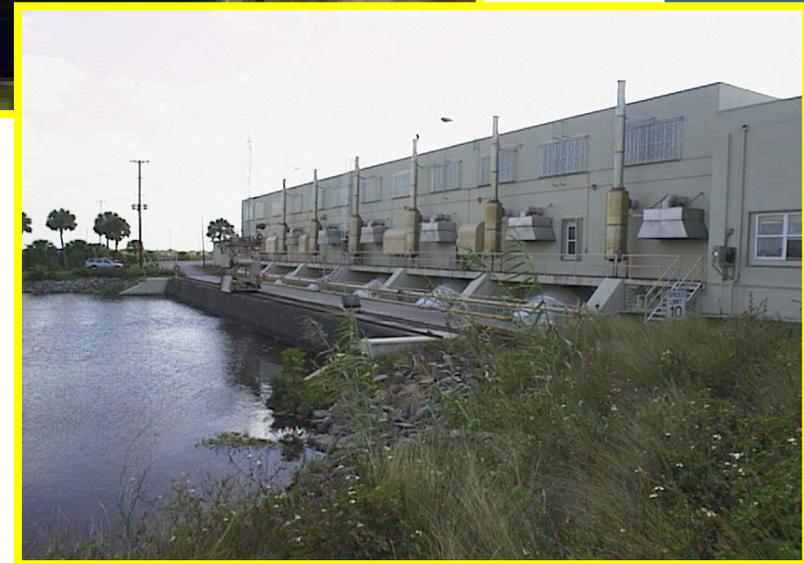
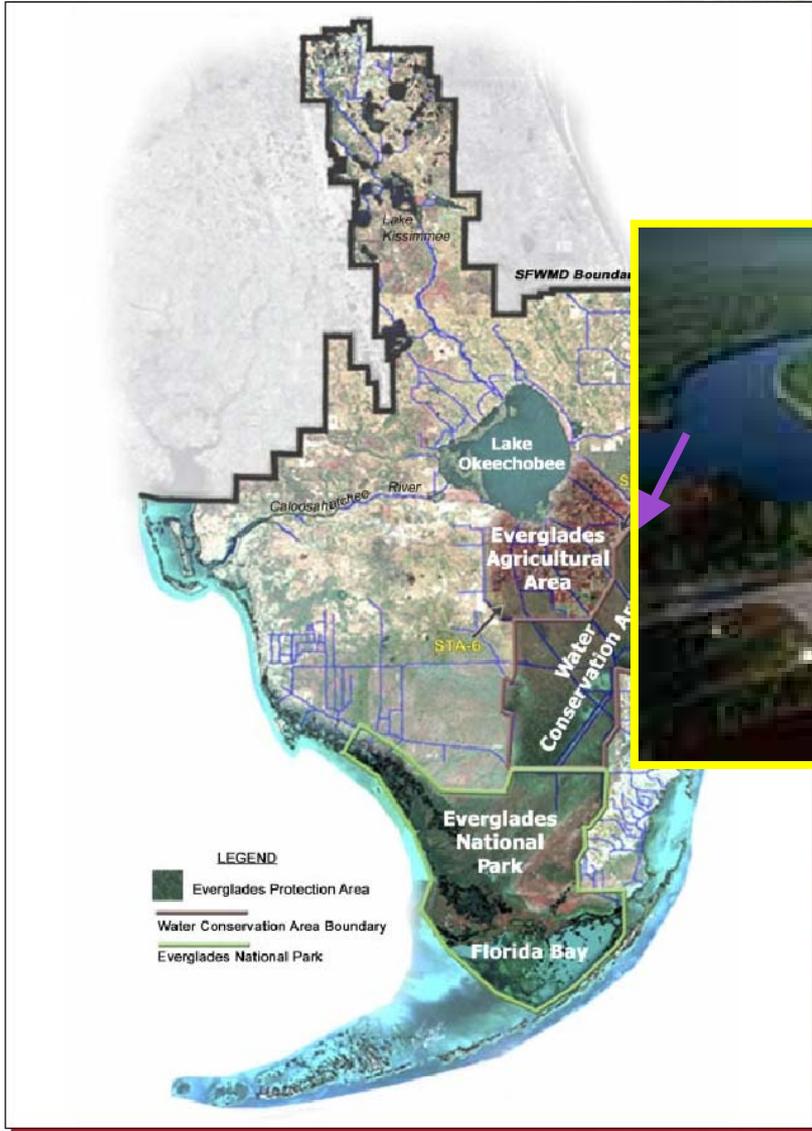
## ■ Consists of six axial flow pumps

- 116 in. dia and rated at 800 cfs

## ■ Pumps surplus water from agricultural area, L-10, L-12 basin into Water Conservation Area 1 (WCA1)



# Location of S-5A



# Importance of S-5A

## Entry point for water into the Everglades Protection Area

- Proximity to the Everglades Agricultural Area (EAA) makes it a receiving point for run-off water from sugar and other farms
- Discharge is used for estimating the water quality
  - Runoff is rich in nutrients – especially **phosphorus**
  - Adverse effect of **phosphorus** on the ecology of Everglades
- Everglades Forever Act (EFA)
  - Developing effective EAA-best management practices that focus on improved on-farm water management techniques and controlled fertilizer application for reduction in phosphorus levels
  - Quantifying eutrophication (excessive plant growth) for water draining into the Everglades



# Sampling Protocol

## ■ EAA-EFA Mandates

- require flow-proportional sampling
- stipulates water quality monitoring system such that total loading of phosphorus can be accurately determined

**Samples must be representative of the overall discharge from the station**



# Current Sampling at S-5A

- Auto-sampler 1 that takes samples in conjunction with pump operation from a fixed location
  - Totalizer triggers sample collection
  - Frequency - once every 32768 rotations
- Grab samples are also taken, about 15 ft. upstream of the pumping station
  - Frequency – weekly
- Another auto-sampler added upstream during 2001



# Limitations of the current configuration of auto-sampler

- Location - The sampler is designed to collect the sample aliquot only from the inlet bay at Pump 4



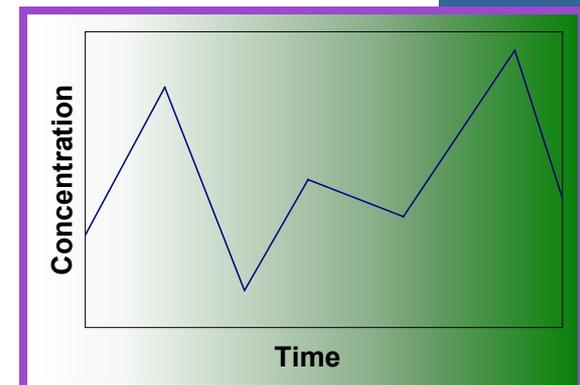
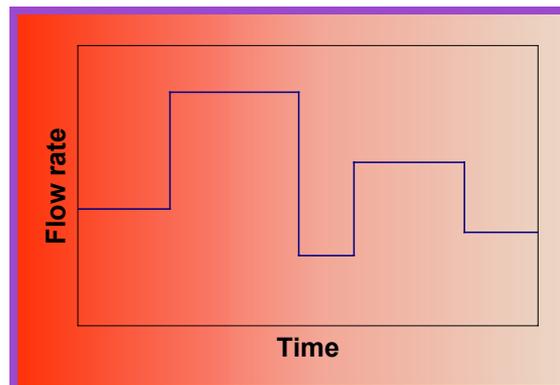
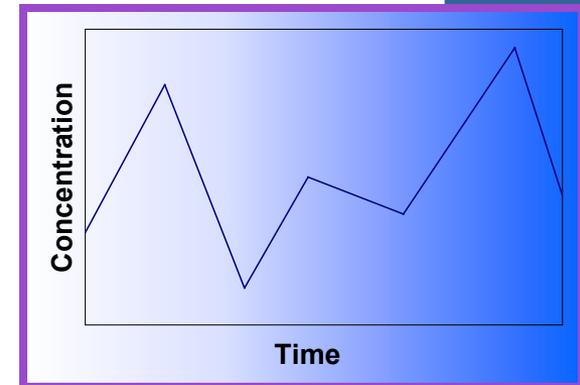
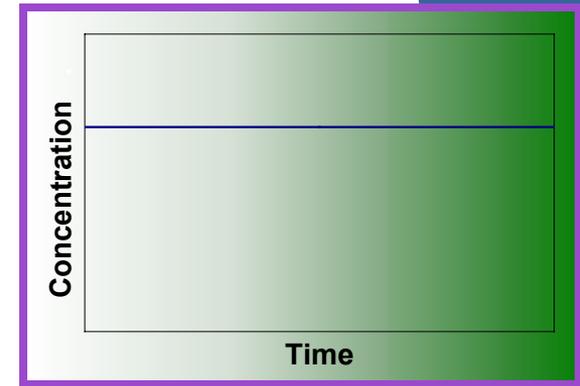
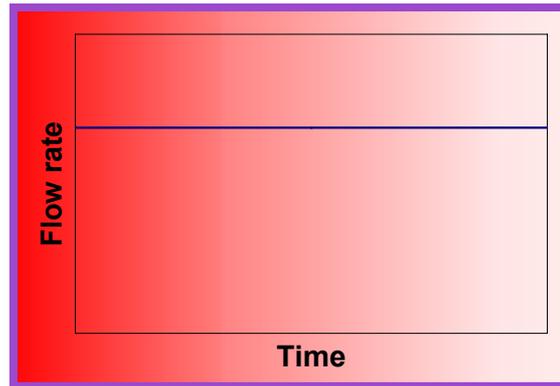
- If pump(s) other than Pump 4 are running, sampling is from a stagnant zone
- Variations in phosphorus concentration with time – might not be adequately captured in the aliquots i.e. the samples collected are not representative of flow
- Total Phosphorus Loading based on such a **sample** is not accurate



# Sampling and Load Determination

## Sampling Situations

1. Constant flow and constant concentration
2. Constant flow but varying concentration
3. Varying flow and varying concentration- flow proportional

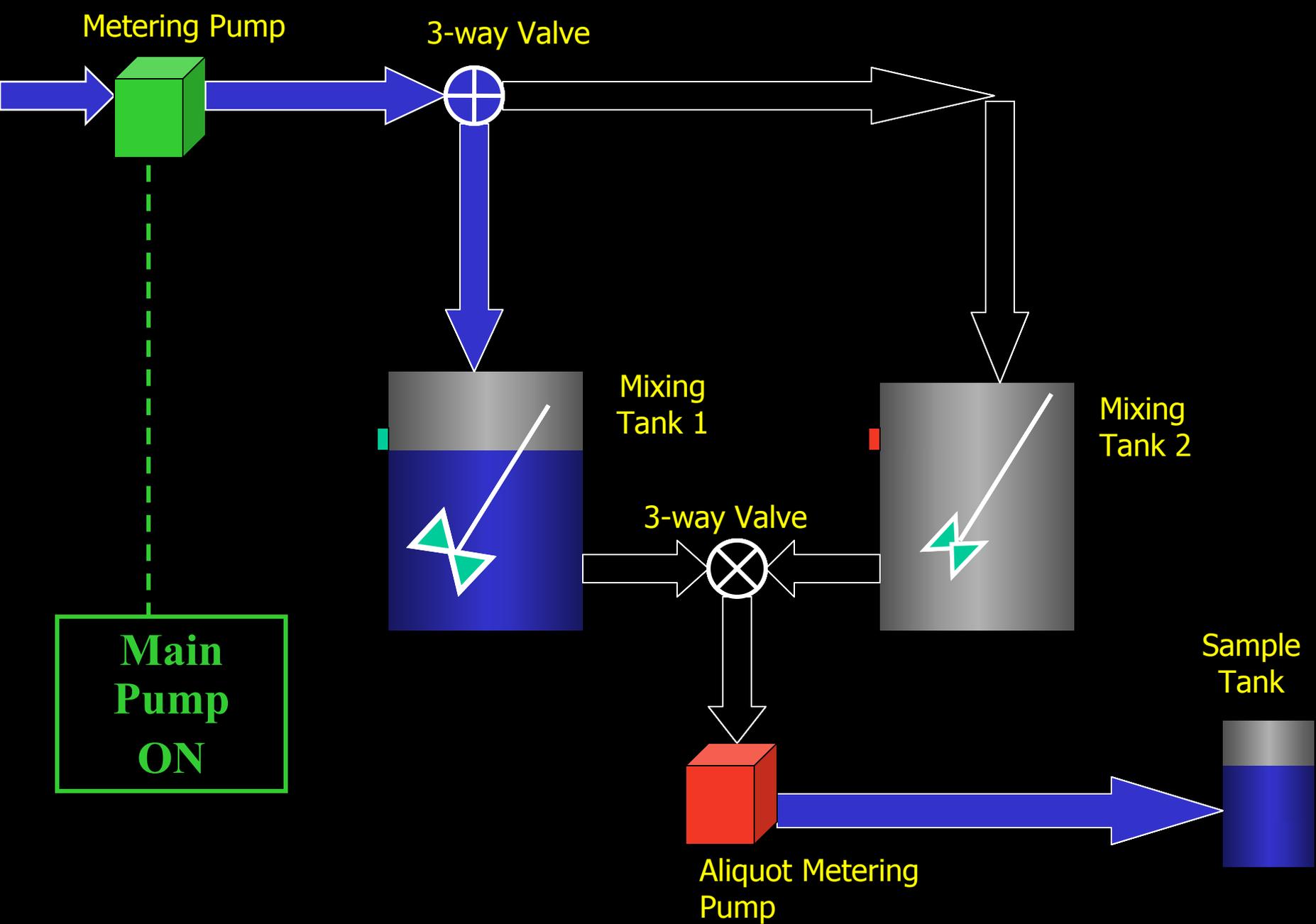


# Basis of the Proposed Total Flow Auto-sampler

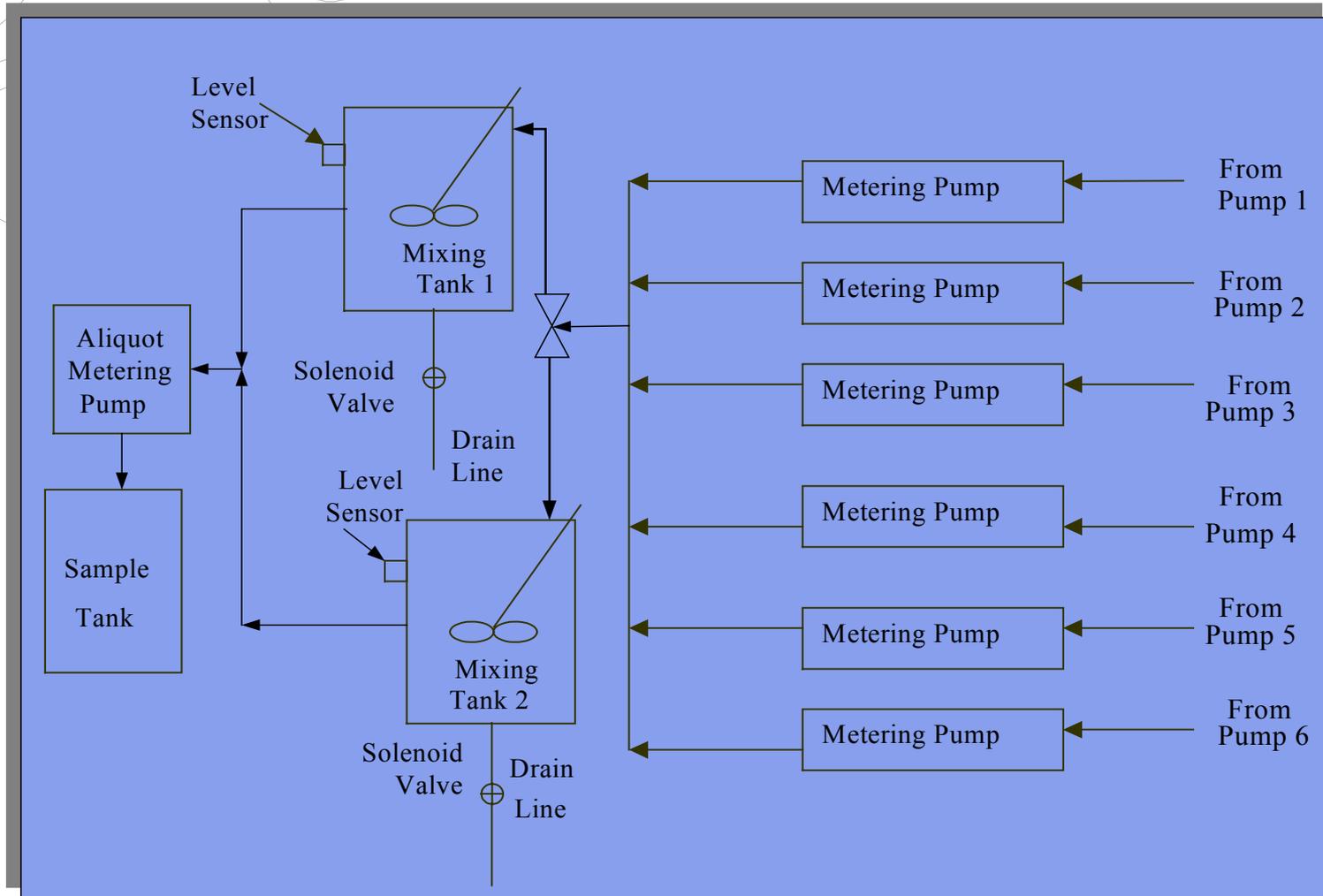
- Representative sampling
  - sample from each operational individual pump
- Flow-proportional
- Continuous sampling of the discharge

**Total Flow Continuous Auto-Sampler**

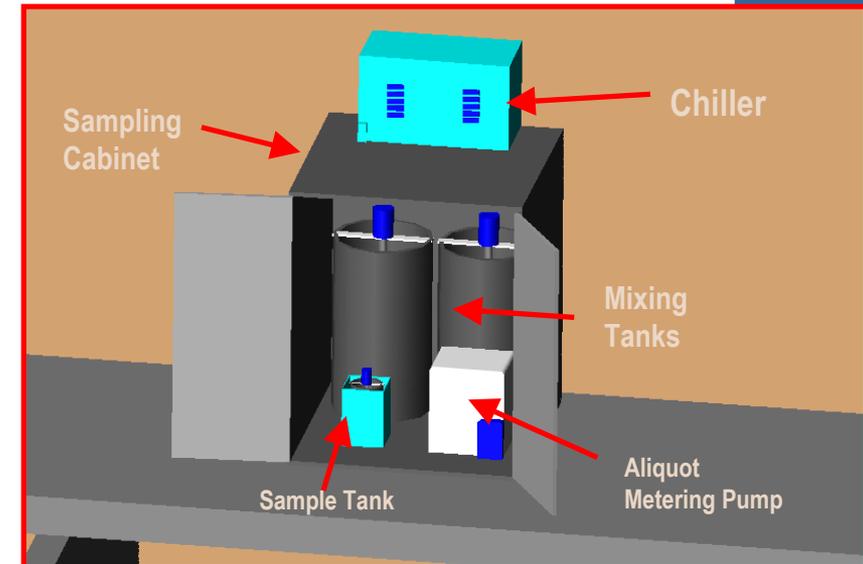
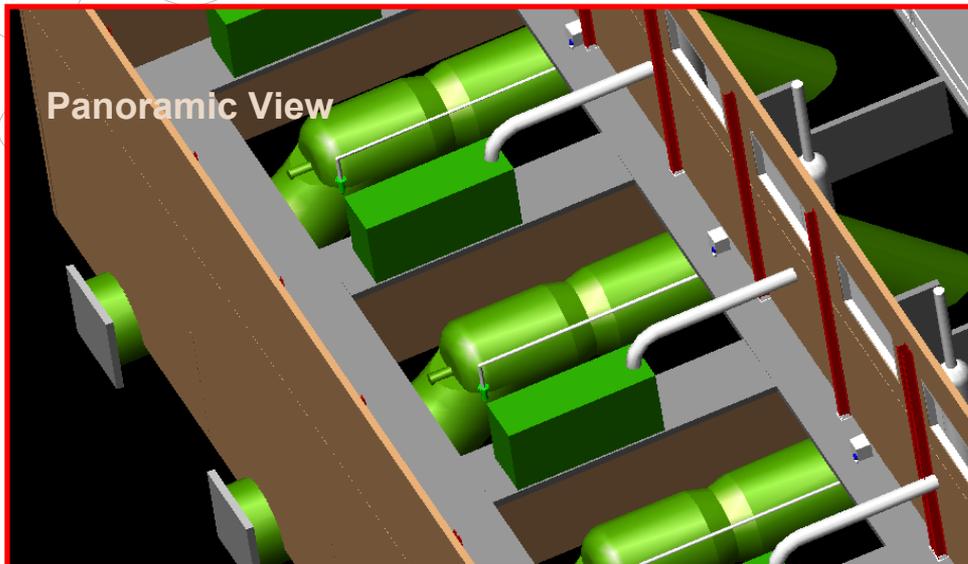
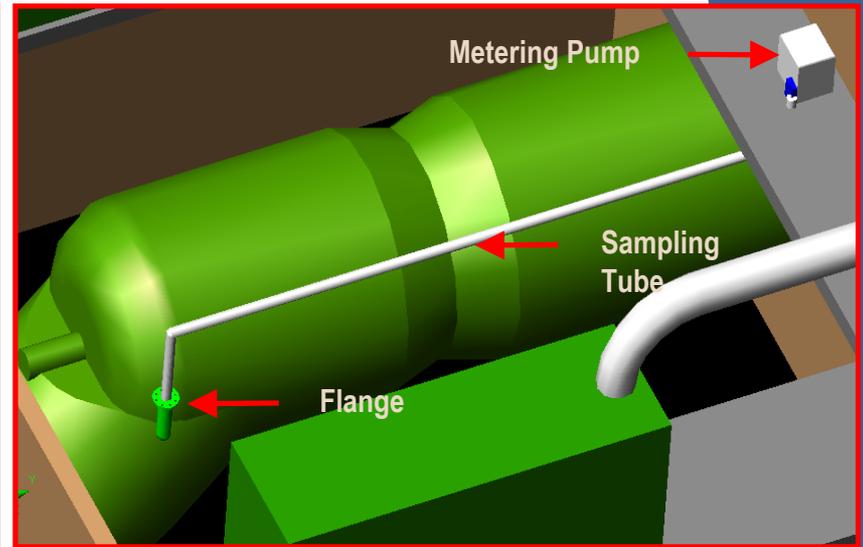
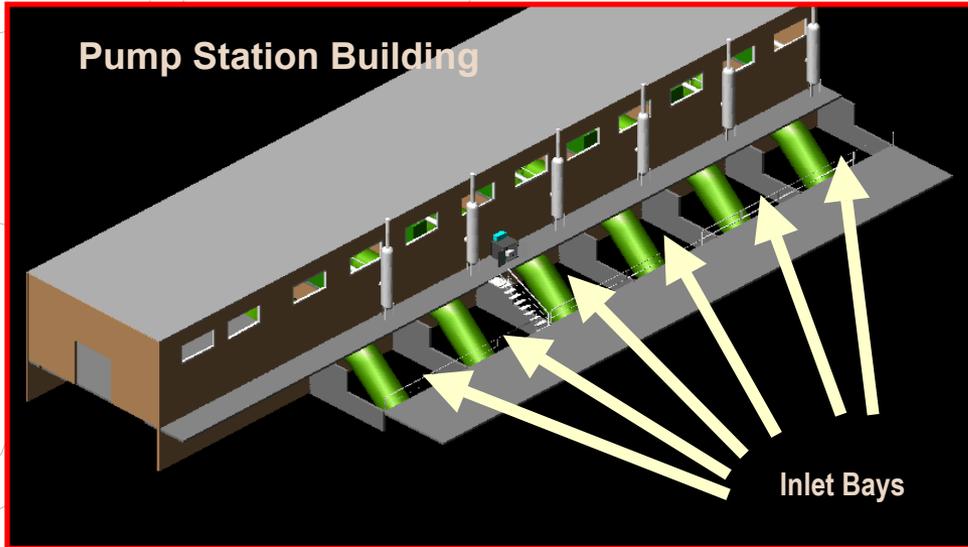




# Proposed Total Flow Auto-Sampler Schematic



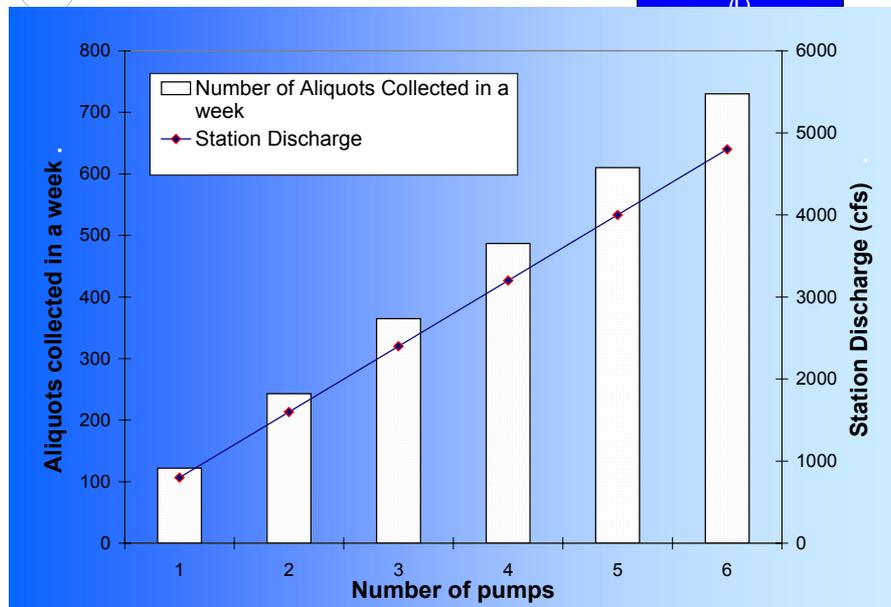
# System Conceptualization



# System Design

- Flowrate in sampling tube - 6 ft/s (max)
- Diameter of sampling tube - 3/8 in.
- Length of sampling tube - 120 ft (max)
- Volume of Mixing tank(s) - 55 gal (208 L)
- Volume of Sample Tank - 10 gal (38 L)
- Volume of each aliquot sample - 50 mL
- Frequency of Aliquot Sampling - Once every 5 minutes (at maximum discharge).

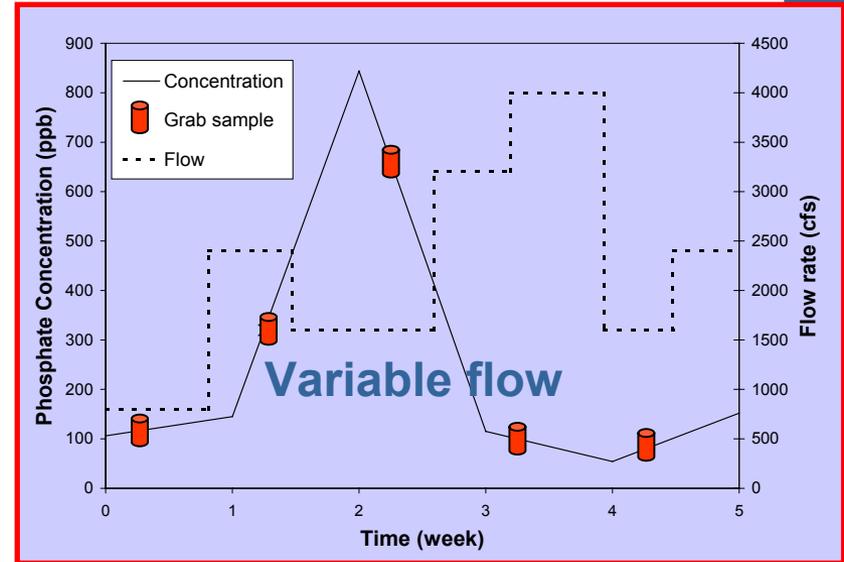
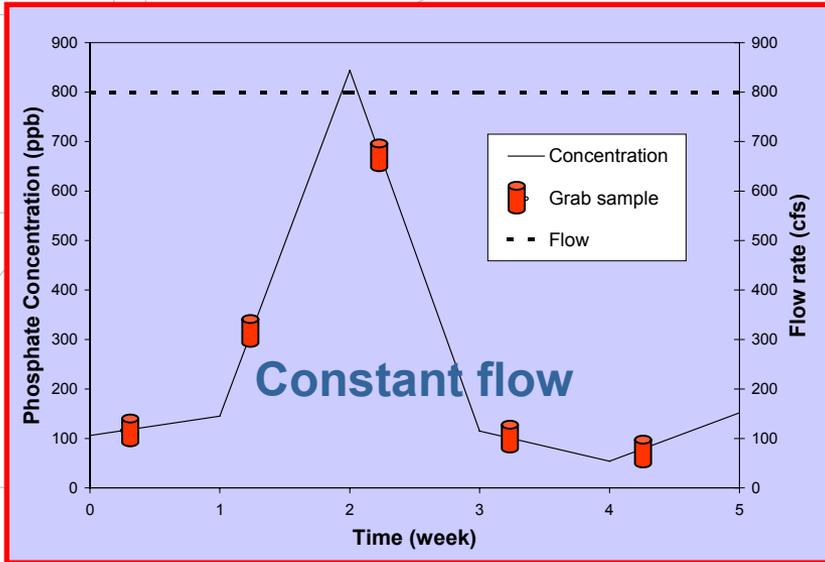
Number of Pumps Running	6	5	4	3	2	1
Station Discharge cfs (Mgal/min)	4800 (2.16)	4000 (1.8)	3200 (1.44)	2400 (1.08)	1600 (0.72)	800 (0.36)
Total Flowrate of Sampling Stream(s) from Pump Bay (gpm)	12	10	8	6	4	2
Residence time in Mixing Tank (min)	4.6	5.5	6.9	9.2	13.75	27.5
Time between Aliquot Sampling (min)	4.6	5.5	6.9	9.2	13.75	27.5
Number of Aliquots Collected in a week (Basis: 8 hrs of operation every day)	730	610	487	365	243	122
Volume of Aliquots Collected in a week Gal (L)	9.6 (36.5)	8 (30.5)	6.42 (24.3)	4.84 (18.3)	3.22 (12.2)	1.6 (6.1)



\* A flow rate of 2 gpm for the metering pump corresponds to a discharge rate of 800 cfs through the main pump



# Error Estimation



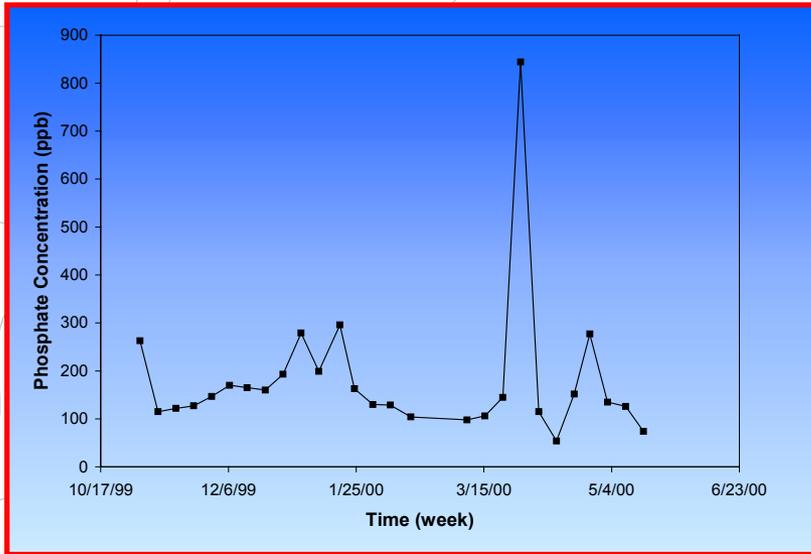
- Error associated with the sampling technique - assuming that there are no measurement or instrument errors
- Variations in concentration with time
- For two cases of discharge:
  - constant discharge
  - varying discharge
- Assumption: Current auto-sampler collects samples that are representative of the discharge

Aliquots collected	Case 1	Case 2
S-5A Grab	5	5
S-5A Auto-sampler	1120	3090
Proposed Total flow Auto-sampler	1832	4784

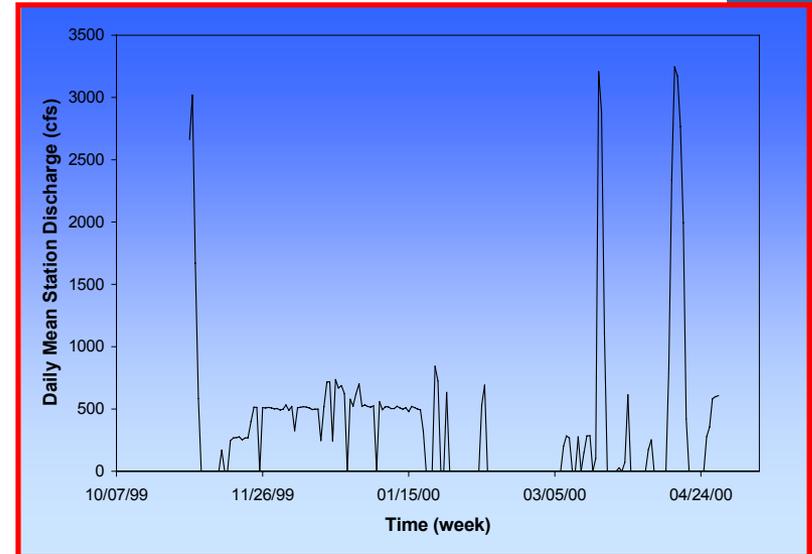
	CASE1		CASE2	
	Loading (Ton)	%Error	Loading (Ton)	%Error
True	1762		431	
S-5A Grab	175	0.9	481	12
S-5A Auto-sampler	176.1	0.06	433	0.6
Proposed Total flow auto-sampler	176.2	0	431	0



# Error Analysis Results



Phosphate concentration based on actual grab samples taken at S-5A, from November 1999 to May 2000 (26 weeks)



Actual discharge from the S-5A, from November 1999 to May 2000 (26 weeks) obtained from DBHYDRO

Source	Relative Error present	Relative Error caused (in determining phosphate loading)
Flow computation	$\pm 10\%$	$\pm 0.5 \%$
Sampling stream flow (metering pump)	$\pm 2\%$	$\pm 0.05\%$
Aliquot metering	$\pm 0.5\%$	$\pm 0.005$
All three combined		$\pm 1\%$

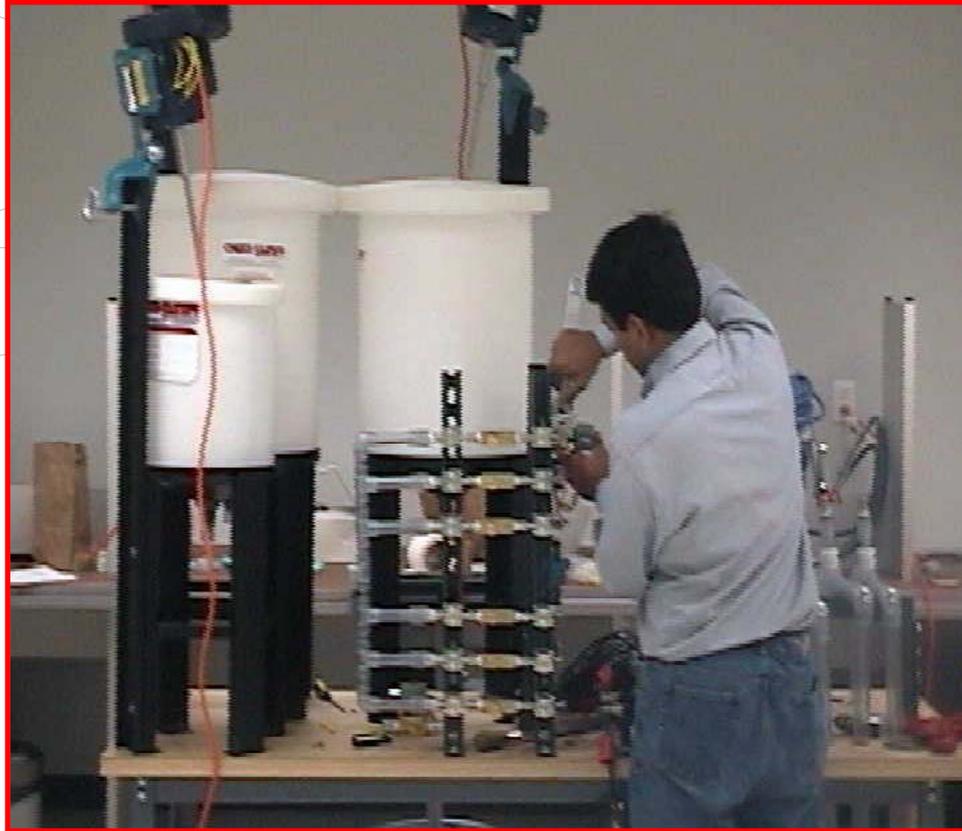


# Proposed Total Flow Auto-Sampler - Summary

- Total flow sampler
  - samples continuously at a rate proportional to the discharge flow
- Capable of sampling from all the pumps, thereby ensuring representative sampling
- Valves and metering pumps easily available (off the shelf) and replaceable
- Completely refrigerated system
- Robust control, data logging and remote query using MOSCAD



# Bench-scale Study

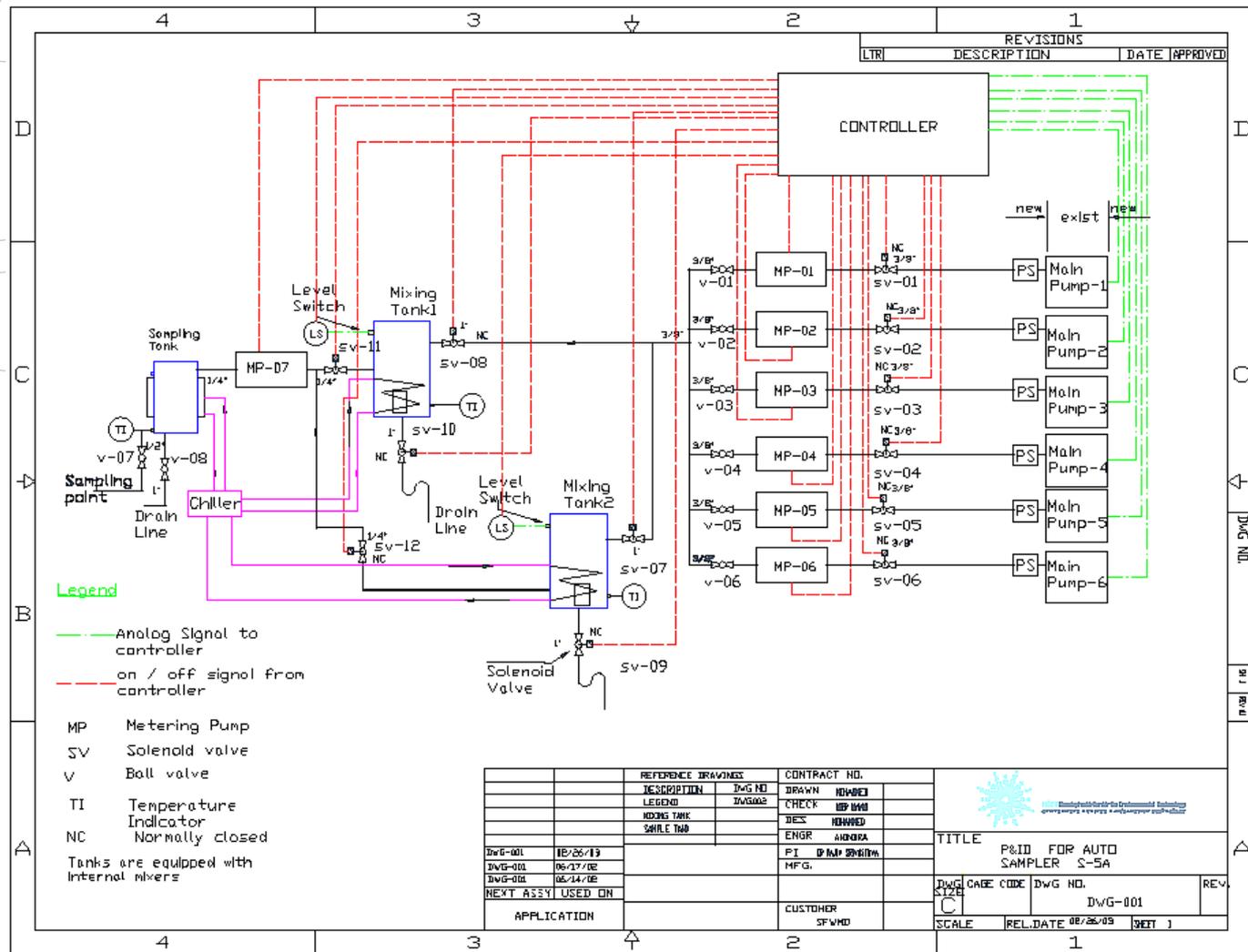


**Concept demonstrated using a bench-scale system**



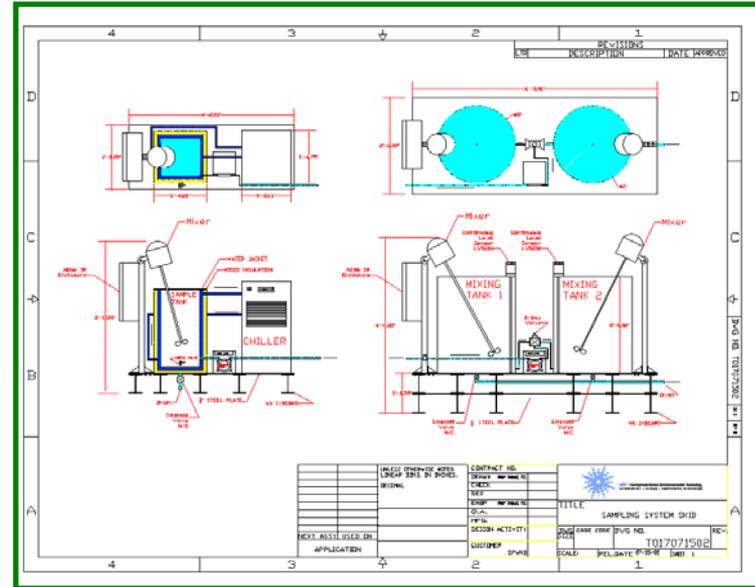
# Total Flow Auto-sampler P&ID

Based on discussions with the technical committee it was decided to use MOSCAD. Documentation detailing the MOSCAD interface of the system complete with it's effectiveness and potential benefits were provided to District.



# Fabrication & Implementation

- System designed to fit onto a skid for easy transportation and installation at site
- Taps for installation are planned to be taken from the pump discharge side sampling port
- Pumps will be supported on the I-Beam near the tap
- Sampling tubes and instrumentation conduits will run on the existing rack

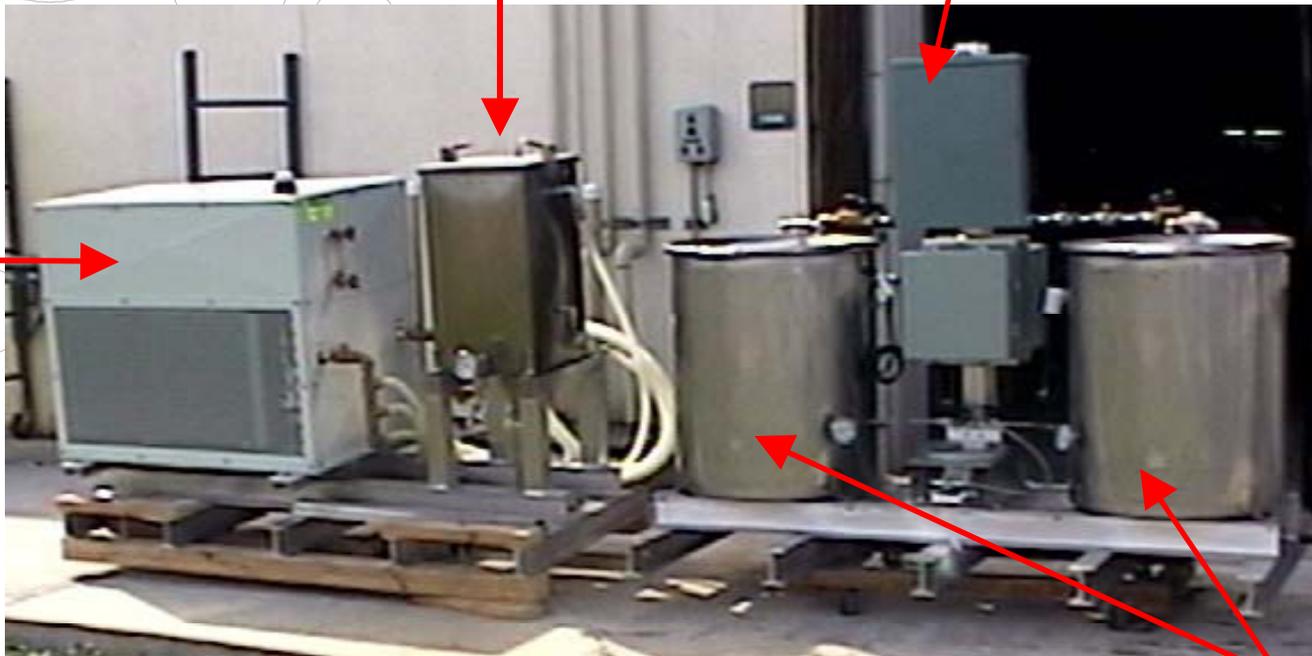


# Total Flow Continuous Auto-sampler

*Sampling Tank*

*Junction Box*

*Chiller*



*Mixing Tanks*



# Contact Information

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