Replacement of Sewer Flume Measurements with Accusonic Transit-Time Flowmeter Network

Accusonic provided a Model 7510 Compound Flowmeter System for wet weather sewer flow monitoring as part of a Phase 1 Demonstration Contract with the Somerset Raritan Valley Sewerage Authority (Bridgewater, NJ). The purpose of the Phase 1 Program was to demonstrate the capabilities of ultrasonic transit-time flowmeters for accurately monitoring highly variable sewer flowrates, particularly under wet weather flow conditions.

The Sewerage Authority maintains seventeen meter chamber sites throughout the multi-community sewerage collection system, carrying inflows to their Polhemus Lane Waste Water Treatment Plant (WWTP). The meter chambers are equipped with Parshall flumes for gauging the flowrate contributions from various community-member trunk sewers connecting to the main interceptors influent to the WWTP. High flow conditions during wet weather periods cause surcharging in the collection system, frequently resulting in backwatering and flume submersion at the meter chambers. This has hindered the collection of accurate flowrate information used for allocation of wastewater treatment costs among the contributing communities.

A complete flow monitoring and data acquisition /telecommunications system was installed in early June 1996 at Meter Chamber No. 4 for the Phase 1 Demonstration Program. The system comprised an Accusonic Model 7510 Compound Flowmeter configured for 3-path transit-time flow measurement within the 27-in-diam (68-cm) sewer pipe influent to the flume meter chamber, ultrasonic level sensor mounted above the existing Parshall flume for dry weather (low flow) measurement, and a data logger/telemodem for the collection and transmittal of flow data to a PC computer system installed at the WWTP. The Model 7510 utilized a pressure gauge for tracking water level within the influent pipe. A tipping-bucket rain gauge was also installed on site to collect local rainfall data, which was logged and transmitted along with the flowrate and water level measurements.

The equipment installed in the sewer environment conformed with applicable National Electrical Code Class I, Division 1, Group D Hazardous Atmosphere requirements. A NEMA 4X (IP65) equipment enclosure was installed on post mounts on the roof of the flume meter chamber to securely house the system electronic components. Voice-grade telephone line service was implemented at the equipment enclosure for automatic transmission of all collected data to the WWTP facility. A back-up power source comprising batteries, charger, and DC-AC inverter was installed in a separate NEMA 4X enclosure for supporting the flow monitoring system during temporary AC mains power outages.

The flowmeter transducers were pre-mounted on a stainless steel sheet-metal sleeve and installed via manhole access to the 27-in (68-cm) sewer pipe. The sewer pipe was flowing about 12-in (30-cm) deep during the installation activities, which required approximately 3-hours of *in situ* work for installing and securing the pipe insert sleeve and performing a final alignment of the transducers. The 3-path transducer configuration provides high-accuracy flow monitoring capability throughout the entire range of dry-to-wet weather flow conditions.

The flowmeter system was in continuous operation during the Phase 1 program period running from early June through mid-September 1996, measuring and recording the complete set of data parameters at 5-minute intervals. Thanks to wetter-than-normal summer weather conditions, a

number of surcharging flume events occurred at Meter Chamber No. 4 during this period, and the corresponding flowrates were continuously measured and documented by the Accusonic flowmeter system.

Several instances of AC mains power outages and disruption of telephone line service did not prevent data recovery, due to the robust system design configuration which provided reliable flow measurement and data recording under these abnormal conditions. On-site data logger capacity was greater than two weeks for the 5-minute sampling of all measured variables.

The recorded data was automatically downloaded to the WWTP PC database via telemodem several times per day during normal operation. When transmission of the data was prevented by telephone service disruption, the recorded data was retained by the on-site data logger until communications were reestablished. The recorded data could also be downloaded via hand-carried notebook computer brought to the site.

As a result of this successful Phase 1 demonstration, a Phase 2 contract was awarded in June 1997 to install the full network of 17 flow monitoring stations with automated data collection and reporting for the Somerset Raritan Valley Sewerage Authority. The complete flow monitoring network was installed and operational by the end of December 1997. These flowmeters have been reliably providing the Sewerage Authority with high-quality flow data via the computerized network ever since that time.

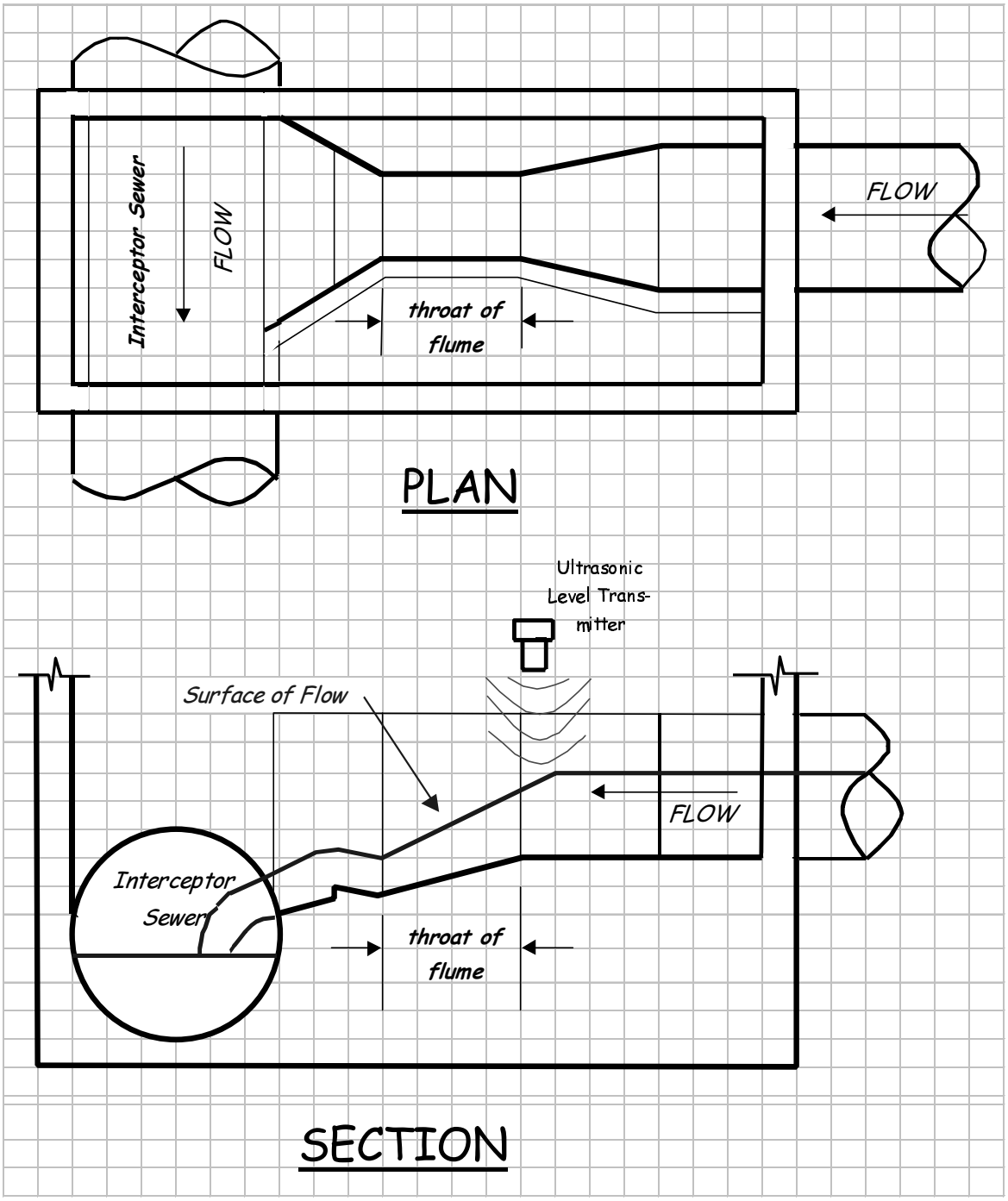
Sleeve installation in sewer. Transducers are pre-mounted on sleeve

Model 7510 Multiple-Path Compound Transit-Time Flowmeter

Discussion of Flume Measurements vs. Accusonic Multiple-Path Transit-Time Flowmeters

Flumes (Critical Depth Devices)

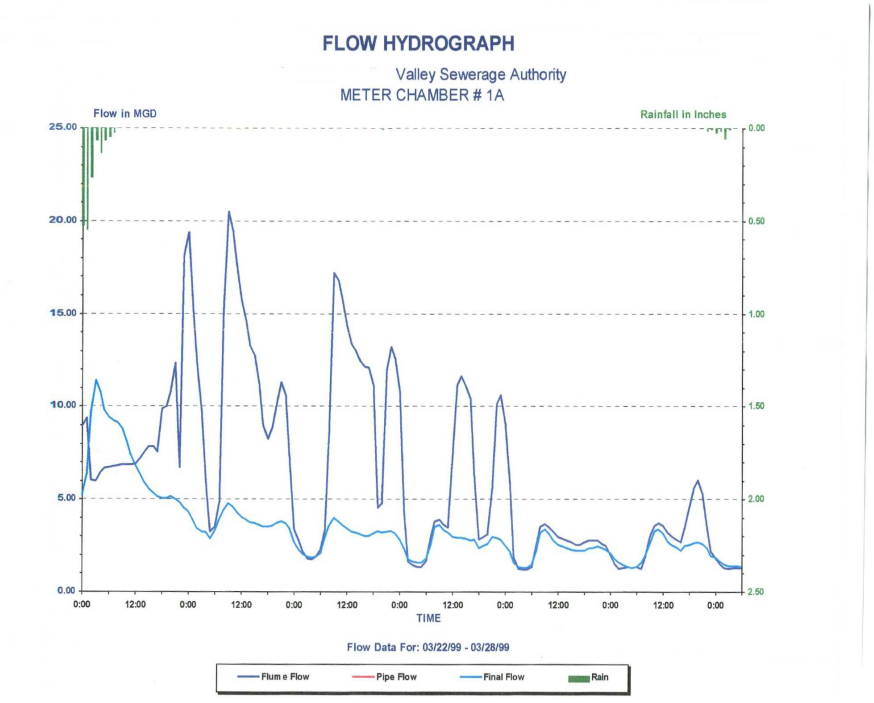
Flumes have often been used as a time-honored way to measure sewage flow. The serious errors to which they can be subject are illustrated in the attached graphs. A sketch of a flume installation is shown below.



A hydraulic engineer must carefully design the flume approach so that the flow from the incoming sewer is slow (sub-critical). As the flow passes through the narrow "throat", the flume floor becomes steep, and the flow accelerates, passing through a stage called "critical depth". At this carefully-engineered point, the velocity-depth relationship is known, so the system needs only to measure the water depth to enable a flowrate determination. The flume measurement system operates according to the design plan only if the design assumptions are not violated. In particular, the flow in the interceptor sewer immediately downstream of the flume chamber must never get so deep that the flume discharge tailrace becomes back-watered or submerged. Unfortunately, such backwatered conditions are very common in real-world sewer systems during wet-weather events that load a sewer system close to capacity. The result of this backwatering may be seen in the flume meter output shown below.

In order to obtain accurate flow data on which to base cost billings for the tributary communities sending flowage into the wastewater treatment plant, the Sewerage Authority installed the most accurate flowmeters available today - *Accusonic Model 7510* multiple-path ultrasonic transit-time flowmeters in the 18 metering chambers comprising their flow monitoring network. The flow reported by the Accusonic meter is shown in light blue. The existing flumes were also left in place, and modern ultrasonic water level sensors were installed to measure the flume depth and create a state-of-the-art flume meter. Thus hydrographs showing the flow as measured by both technologies may be viewed together, as shown in the hydrographs presented below.

The reliability of the flume measurements under normal dry-weather conditions is shown by the regular daily fluctuations in the dark blue flowrate hydrograph based on the flume measurements. But the design assumptions for good flume flowrate measurements are clearly being violated under the wet-weather sewer system flow conditions - deep or surcharged flow from the interceptor is back-watering into the flume, causing subcritical flow in the flume, and thus the flume-reported flowrates are seen to be as much as 4 times higher than the actual flow.



Over-reporting of flow is not the only way that flume-based flow measurements can be in error.

A flow hydrograph from another of the sewer monitoring network flume chambers is presented below. The upper flow curve shows the *Accusonic* meter record, and the lower curve represents the flume. The daily fluctuation reported by the flume reliably "tracks" the precise "*Accusonic"* record, but is reporting a flow consistently 30% to 50% too low.