The Evolution of Collection System Best Practices

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Abstract

The wastewater collection profession is experiencing rapid change. As new technologies, operating procedures, and workarounds are introduced, collection agencies are facing increasingly stringent environmental regulations, aging infrastructure, a changing workforce, heightened exposure in social media, climate change, and scrutiny from customers, requiring that industry ‘best practices’ continually evolve.

How does our profession become aware of, evaluate, and implement changes to existing practices? How do these changes impact the workforce and workplace, and how do workforces and workplaces influence changes that are made? When should new business practices and technology advancements become generally accepted? These are all important questions to be considered, especially when evaluating the applicability of best practices, adopting new technology, standardizing procedures, and providing industry-wide training.

One of the most highly regarded water and wastewater operator training programs in the United States has been working hard to ensure that wastewater collection systems ‘best practices’ are up-to-date, relevant, and appropriate.

First published in 1975, and with nearly 90,000 copies in print and used by over 25,000 operators and managers in accredited training programs, the OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, Volumes 1 and 2, have undergone several complete revisions throughout the years.

Under the auspices and supervision of the Office of Water Programs, California State University, Sacramento (CSUS), a team of dedicated industry veterans has been using a painstakingly thorough approach to keep its operators and manager training manuals current.

While Volume 1 was being distributed in its Sixth Edition at the time of this writing and Volume 2 was distributed in its Seventh Edition, this paper describes a ‘behind-the-scene’ look at the often-mysterious process used to create the new addition of Volume 1. Due for release in 2015, with principal work complete, this paper provides a glimpse in how best practices are created, identified, and documented for the wastewater collection industry.


This paper was presented by Ken Kerri, Ph.D., P.E., at WEFTEC, Chicago, IL in October 2014. It represented his last publication before his passing in December 2014. We wish to thank Dr. Kerri for his tireless contribution to the industry, his series of Operation and Maintenance manuals, and legions of students he influenced during his career.
Introduction

The wastewater collection profession is experiencing rapid change. As new technologies, operating procedures, and workarounds are introduced, collection agencies are facing increasingly stringent environmental regulations, aging infrastructure, a changing workforce, exposure in social media, climate change, and scrutiny from customers, requiring that industry ‘best practices’ continually evolve.

One of the most highly regarded water and wastewater operator training programs in the United States has been working hard to ensure that the collection systems best practices reflected in its courses are up-to-date, relevant, and appropriate.

First published in 1975, and with nearly 90,000 copies in print and used by over 25,000 operators and managers in accredited training programs, the OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, Volumes 1 and 2, have undergone several complete revisions throughout the years.

Under the auspices and supervision of the Office of Water Programs, California State University, Sacramento (CSUS), a team of dedicated industry veterans has been using a painstakingly thorough approach to keep its operator and manager training manuals current. With Volume 1 currently being distributed in its Sixth Edition, Volume 2, the Seventh Edition of Volume 1 was scheduled for release in December 2015.

The demand to identify best practices and to keep supporting training manuals current comes from many sources, including:

• Regulatory agencies responsible for ensuring compliance with collection system safety regulations and also environmental and public health protection regulations,
• Collection system agencies using the manuals for training and system O&M, troubleshooting, and safety programs,
• Changes in the workplace, including its extended diversity, introduction of performance measurement systems, and graying of the workforce, sometimes resulting in regional consolidation of sewer agencies,
• Regional (geographic) work standards and preferences,
• Accreditation boards responsible for overseeing the certification of collection system operators,
• Growing trend of distance education training programs,
• Commercial vendors wishing their new products and technologies to be included in the training manuals.

Designed to train personnel in the safe and effective operation and maintenance of wastewater collection systems, Volume 1 (Figure 1) emphasizes tasks performed by line maintenance crews and covers various types of collection systems and construction inspection. Volume 2 (Figure 2) shifts emphasis to lift stations, maintenance, and administration.
From Idea to Action

All good things start first with an idea. And so it began with the creation of the OPERATION AND MAINTENANCE SYSTEMS manuals, including outside hounding, pestering, cajoling, and pleading.

As early as 1967, then Associate Professor, Kenneth Kerri, Ph.D., P.E., sitting in his office at Sacramento State College, recalls Bob Reed, Walt Driggs, John Brady, and Norm Farnham – all young wastewater treatment plant operators – saying ‘we want you to do a manual on how to teach us to do our jobs.’ Continuing the impromptu roundtable, the group said that ‘Managers know how to take certification exams, and Engineers don’t know how to operate treatment plants.’ But, Dr. Kerri recalls saying, “I’m just a professor, I don’t know anything about operating a treatment plant.”

After continued pestering and promises for ‘once a week’ meetings – driving from all parts of Northern California, representing sewer agencies from Lake Tahoe, Fairfield, Modesto, Redding, Sacramento, and Stockton – Dr. Kerri reluctantly agreed, with the condition that everyone else would do all the work and write everything down, so he would only have to shuffle the papers.

Weekly discussions started with a topic, such as lift stations, manholes, collection systems, treatment plants, etc. and asked the question, ‘what would you tell a new person that knew nothing about.’ With early meeting notes written in longhand, soon organized meetings began with oral presentations that were recorded, transcribed, typed, and circulated. Vendors were invited to participate and share photos, drawings, and troubleshooting tactics to operate and maintain their equipment.

By 1972, the core team included Bill Dendy, Bill Crooks, John Brady, and Dr. Kerri, with the Collection Systems Committee, particularly Rick Arbor from Minnesota and Richard Thomasson from Washington Suburban Sanitation Commission, reviewing and editing draft manuscripts.

Noting the importance of adopting key requirements to create a successful teaching environment, professors in Education, including George Gardener and Larry Hanna from California State University, Sacramento, were enlisted to show how to learn a topic.

Following the successful results from the EPA’s national field study training program, OPERATION OF WASTEWATER TREATMENT PLANTS, a similar effort appeared needed for wastewater collection system operators. In cooperation with the California Water Pollution Control Association, the project directors prepared and submitted a proposal to the EPA for financial support through the Foundation of California State University, Sacramento.

Chapters were written, presented at small information seminars, reviewed by consultants and reviewers throughout the United States, field tested by potential and experienced collection system operators, reviewed by the EPA, and revised after each step in accordance with the suggestions and experiences gained from all sources.

While the EPA paid for the development of original course material, ongoing training and subsequent editions were self-funded from sale of manuals and enrollment in courses.
The First Four Decades

The first edition of the OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS was published in 1976. Referred to as a home study course, the first edition’s Preface stated that the purpose of the wastewater collection system course was to:

1. Develop new qualified wastewater collection system operators,
2. Expand the abilities of existing operators, permitting better service to both their employers and the public, and
3. Prepare operators for civil service and CERTIFICATION EXAMINATIONS.

The scope of each successive manual included:
1. What collection systems are expected to achieve,
2. Why wastewater collection systems must be properly operated and maintained,
3. What the collection system operator is expected to do to keep the collection system functioning as intended,
4. How to inspect and test newly constructed sewer and new and old wastewater collection systems,
5. How to locate and evaluate problems such as stoppages, leaks, odors and lift station failures,
6. Selection of procedures and equipment to correctly identify problems and to minimize recurrence of problems and failures,
7. How to operate & maintain inspection and cleaning equipment,
8. Methods of selection and application of chemicals,
9. Procedures for operating, maintaining and repairing collection systems,
10. Instructions for operating, maintaining, troubleshooting and repairing collection system equipment and facilities such as lift stations,
11. Techniques for recognizing hazards and developing safe procedures, and
12. How to organize and administer the operation and maintenance of wastewater collection systems.

Early versions of the manual (Figures 3 & 4) established the foundation for successive manuals. The manual was originally designed to allow for a self-paced instruction where operators work at their own speed. But, once collection system operators started using the manual for home study, they realized that it could serve as a textbook in the classroom.

Colleges and universities used the manual as a textbook in formal classes, often supplemented by case studies offered by field supervisors and operators.

Where colleges were not available, utility agencies and local chapters of wastewater organizations joined together to offer their own courses using the manual.

In order for the operator to certify successful completion for each chapter, objective tests and special answer sheets were provided when enrolled in the course. Rather than utilizing Multiple Choice, Fill-in-the-Blank, or True-False question formats, the manual used a narrative question and answer format (Figure 5).

In classrooms, instructors helped to answer questions when a person in the training program had questions or needed assistance. Instructors then graded objective tests at the end of each chapter, recorded scores, and notified the Office of Water Programs at the California State University, Sacramento (CSUS), of the scores when a person successfully completed the program; avoiding any long wait while papers were graded and returned by CSUS.

Recognizing the multi-cultural backgrounds of wastewater collection operators, previous educational experiences of course participants, and slightly different meanings in some regions of the United States, Warren Prentice was
first to propose and author a section on key word pronunciations. Designed solely to aid operators, words were
often explained differently from the WEBSTER’S NEW WORLD COLLEGE DICTIONARY, Figures 6 and 7.

A pronunciation chart was also included that underwent ongoing review and content analysis as shown in Table 1.

Today, with 87,600 copies in print (Figure 8, Tables 1 and 2), nearly every collection system library, workbench, and book-
shelf, include a copy of one or both volumes of OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION
SYSTEMS.

Review Procedures

A key factor in the successful writing, editing, and publishing of a ‘best practice’ training manual is the ability
to attract a cross-section of subject matter experts willing to enter into a collaborative review process. Collection
agencies in California provided a solid cross-section of the U.S. collection market, including size (i.e., large
and small), climate (i.e. wet and dry weather), maturity (i.e. area-bound and new developments), land (i.e. coastal
and inland), and disciplines (i.e., administrative, engineering, operations, human resources, and financial).

For many years prior to the 1976 publication of the first edition of the OPERATION AND MAINTENANCE
OF WASTEWATER COLLECTION SYSTEMS, Volumes 1 and 2, the Water Pollution Control Federation, its
member associations, state and local utility agencies, and colleges and universities sensed a need for improve-
ment in the dissemination of information on the operation and maintenance of wastewater collections.
They felt a need for better training opportunities in the field; however, because of the lack of communication
between the practical people doing the work in the field and the professional people in charge of publishing and
training activities, the dissemination of information and training in the collection system field had been, until a
few years earlier, almost negligible compared to that in the wastewater treatment plant field.

Prior to publishing the first edition, F. J. Ludzack, National Training Center, Office of Water Program Operations,
and the EPA, offered many technical improvements. Dr. Elie Namour, author of the EPA’s “Manpower Manuals for
Wastewater Collection Systems,” reviewed the manpower aspects of the manual. Robert Rose, Program Manager,
Chief, State and Local Training Activities Section, EPA, served as an additional source of information and guidance.
Figure 8. Volume 1 – Print History, By Edition

Table 2. Volume 1 – Print History

<table>
<thead>
<tr>
<th>Year</th>
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</tr>
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<td>First</td>
<td>5,000</td>
</tr>
<tr>
<td>1987</td>
<td>Third</td>
<td>First</td>
<td>8,000</td>
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<td>1991</td>
<td>Third</td>
<td>Second</td>
<td>8,000</td>
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<td>1996</td>
<td>Fifth</td>
<td>First</td>
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<tr>
<td>1999</td>
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<td>Second</td>
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<tr>
<td>2008</td>
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<td>2013</td>
<td>Sixth</td>
<td>Third</td>
<td>3,000</td>
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TOTAL PRINTING 87,600

Table 3. Collection System Course Enrollments, 1991-2013

<table>
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<th>Year</th>
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<td>1993</td>
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<td>1997</td>
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<td>1998</td>
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<td>507</td>
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<td>2012</td>
<td>831</td>
<td>613</td>
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<tr>
<td>2013</td>
<td>694</td>
<td>450</td>
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TOTAL 17,939 11,119 9,268 5,449
No training book or manual can hold the attention of a reader if limited to just words; and the Collection Systems manual was no exception. With drawings by Martin Garrity, and sketches and line drawings by George Gardin and Sue Hashimoto, some of the best comments have been from its fanciful, almost comedic illustrations (Figure 9).

![Figure 9. Using CCTV to Inspect Sewer Pipes, 1982](image)

Even the printer, Dave Clark, became a key player. As publisher of over 40 monthly magazines, campaign printer for both Democratic and Republican elected officials, and sports program printer for the San Francisco 49ers, San Francisco Giants, Oakland Raiders, and Oakland A’s, Dave Clark offered off-peak printing rates and schedules for every manual that has been printed. Suggesting that a color photograph be included on the cover, a University photographer was tasked to provide photos of field crews.

By 1987, Program Director, Ken Kerri, wrote how collection system operators had always survived by their wits and ingenuity. But, the tone of the manuals changed modestly to emphasize how operators were applying more advanced technologies to operate and maintain wastewater collection systems.

Closed circuit television (CCTV) inspection technology – at that time – in use for almost 20 years, was gaining unprecedented acceptance by collection operators, with manufacturers introducing better lighting, higher camera resolution, and increased mobility, that allowed operators to share visual observations and create common defect identification standards (Figures 10 and 11).

The CCTV technology used to inspect and record the status of collection systems is continually advancing. New instruments whose precision and reliability continued to improve over previous models, showed why authors, vendors, consultants, educators, reviewers, and operators, needed to work together to describe and integrate new products and techniques into later editions.

![Figure 10. Problems Seen By CCTV, 1987](image)

![Figure 11. CCTV Inspection Codes, 1987](image)
As personal computers migrated from the office into utility vehicles, a new set of roles and responsibilities crept into the lives of wastewater collection system operators, given a new tool to locate, inventory, and maintain information to create a history of collection system assets. Previously limited to paper-based as-built maps stored in an engineer’s drawer, operators soon became the front line to record work activities, conditions, and costs, able to be assigned to specific assets.

Advancements in technology allowed collection system operators to perform more and more tasks without having to enter confined space of manholes or sewers, thus reducing the risk of exposure and other safety hazards. While the manual was first published in 1976 as a single volume, the manual was expanded by 1996 to require the addition of a second volume.


For the most recent editions, work began in 2012 by nationally known and recognized collection system thought-leaders, including selected collection system experts, consultants, national associations, and commercial vendors, for their respective chapters, including:

**California Collection System Agencies**
- Sacramento Area Sewer District, John J. Hough & Randy Cannedy
- City of Sacramento, Department of Utilities, Robert Jack
- City of Los Angeles, Robert Potter
- Eastern Municipal Water District, Mark Chamberlin
- Union Sanitary District, Shawn Nesgis

**National Perspective**
- Tilson & Associates, Stephen B. Tilson
- Blue Heron Engineering, Laurie Chase

**Vendor**
- Technology - Former CEO Hansen Information Technologies, Chuck Hansen

As the wastewater collection industry continues to undergo change, end-users, subject matter experts, and editors are constantly on the lookout for better ways of getting things done. As municipal budgets get tighter, knowledgeable operators retire, and vacancies go unfilled, the need to adopt more efficient and effective best practices has never been greater.

Some industry changes represent incremental product innovations; smaller-scale improvements, extensions, or refinements of existing products that tend to have a certain ritual, rhyme, rhythm, or reason. Higher resolution CCTV cameras, improved flow monitoring algorithms, and enhanced user controls for jet trucks, represent just some incremental innovations. Often quite predictable, long-time established companies often introduce these improvements at regular intervals that are tested, reviewed, and substituted for older, legacy models.

Start-up companies, in contrast, pursue “innovation” as their whole business; developing products outside of large company bureaucracies, oftentimes creating breakthrough products that utilize new technologies or that may be disruptive to longstanding products. The use of distributed fiber optics, pressurized flood grouting, adhesion-based epoxy liners, acoustic sensors, and electro scan, are all examples of emerging technologies from nimble new entrants.

**Case Study: Electro Scan, Twenty Years of Product Evolution Leading to the Seventh Edition**

Development of a new condition assessment method, known as Electro Scan, began its journey in the 1990s. Scheduled to be included in the upcoming 7th Edition of the OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS, Volume 1, the new technology got its fledgling start in 1995 as a German government-funded research project that was unable to deliver consistent results and soon abandoned. Recognizing the need for more precise data capture, storage, and data processing, intellectual property was acquired in 2011 to re-engineer the solution, followed by field testing, EPA benchmarks, and customer trials.
Electro scanning is carried out by applying an electrical potential (voltage) between an electrode (probe) released inside an electrically non-conductive pipe (e.g. asbestos cement, brick, clay, plastic, reinforced concrete, liners, etc.); while on the same circuit, a grounding electrode is placed in the ground, near the surface, or attached to a metal pole.

CCTV inspection has been a dependable dry weather visual assessment tool that depends on trained operators to identify subjective defects based on NASSCO’s PACP standards. In contrast, electro scan represents the first tool that automatically assesses pipe conditions – in wet or dry weather – able to locate & measure defects, not often visually identified, especially in post-rehabilitated pipes.

Providing there are no defects or leaks in a pipe, electric current is prevented from flowing from inside a pipe to outside ground (i.e. no pathway linking the inside of a pipe to ground); however, if there is any defect that allows a pathway between the electro scan probe (inside the pipe) and ground stake (outside the pipe, located on the surface), an electrical resistance of the current path will determine the size (i.e. height of defect current, including start and end), location, (i.e. within .04 inches or 1cm), and measurement – in Gallon per Minute (GPM) or Liters per Second (L/S) within ± 40% accuracy, in quick succession (i.e. 45-60ft per minute) to find each defect.

Data includes a Total Pipe Defect Flow in GPM and Total Gallons per Day per Inch Diameter Mile (GPD/IDM).

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1995</td>
<td>First German patent applications based on government funding.</td>
</tr>
<tr>
<td>2003</td>
<td>First U.S. prototype of FELL-21 and FELL-41 developed by Robert Harris.</td>
</tr>
<tr>
<td>2004</td>
<td>WERF – An Examination of Innovative Methods Used in the Inspection of Wastewater Systems, featuring Section 5.1.5.1 Focused Electrode Leak Location System (FELL-41).</td>
</tr>
<tr>
<td>2006</td>
<td>Multiple papers published &amp; presented at ASCE Pipelines Conference. ASTM F2550-06 – Approved.</td>
</tr>
<tr>
<td>2010</td>
<td>EPA State of Technology for Rehabilitation of Wastewater Collection Systems, EPA/600R-10/078, published, including Electro Scanning.</td>
</tr>
<tr>
<td>2014</td>
<td>New lesson outline finalized, written, reviewed, and submitted for editorial review.</td>
</tr>
<tr>
<td>2015</td>
<td>Expected publication of Seventh Edition of VOLUME 1, OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS.</td>
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</tbody>
</table>
After completing hundreds of thousands of linear feet of pipe – including different diameters, pipe types, pipe materials, and conditions – electro scan was also found to be superior to finding defects in post-rehabilitation lining projects, specifically the ability to detect cracks, defective joints, faulty service connections, undetected punctures, over-cooked, and defective liners, not found by CCTV.

In 2006, the electro scan process was awarded ASTM standard F2550-06, Standard Practice for Locating Leaks in Sewer Pipes Using Electro Scan – the Variation of Electric Current Flow Through the Pipe Wall.

Following over 100 projects conducted in the United States, England, New Zealand, Australia, Switzerland, and Japan, electro scan’s standard of practice was expanded to recommend pre- and post-rehabilitation assessments, as published in ASTM F2550-13, Standard Practice for Locating Leaks in Sewer Pipes By Measuring the Variation of Electric Current Flow Through the Pipe Wall.

In November 2013, Ken Kerri invited Electro Scan Inc. (Sacramento, California) to contribute to a new chapter in the upcoming Seventh Edition of the manual. In use by dozens of wastewater collection systems and gaining worldwide acceptance with operators, meetings were scheduled in late 2013 and early 2014 to outline general requirements, content, and writing style that would guide chapter development. Beginning with the exchange of multiple text-based draft documents, further drafts included diagrams, site photographs, and tables, leading to a pre-press chapter to be reviewed by other editors, Figure 13.

**Editorial Process**

The Editorial Staff at the Office of Water Programs, California State University, Sacramento, has become an integral part of creating previously published and current editions of OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS. The Editorial Staff must ensure the delivery of a cohesive, well-written, and relevant document that must address and represent the state of the collection industry. This section will discuss the final stages of managing the process.

Throughout the history of developing its manuals, the Office of Water Programs at California State University, Sacramento, has been the focal point for keeping operator training manuals current, including the editing of materials and preparation of manuscripts for printing, correction of printer’s proofs, coordinating production of the manual, overseeing all administrative details, sales, shipments, and deliveries.
Lessons Learned

Many lessons have been learned since the publication of the first manual in 1976 and issuance of the first certificate (Figure 14) of course completion in 1977.

Many stories have emerged during the course of the home study course of distinguished students. But, none as inspiring as a letter once received from a person incarcerated at a State Prison. Damaged manuals are routinely provided free of charge to prisoners, with one such manual provided to a young man that was a self-described former drug-addicted, armed robber, that wrote a letter to Ken Kerri asking if someone like him could ever hope to become a wastewater collection operator. Completing the self-study course and paroled from prison, that student is now a manager of a leading wastewater utility.

“If you study our manuals, you can manage a big utility,” states Ken Kerri.

Given the risk of obsolesces that may occur as soon as the latest edition is sent to the publisher, the Office of Water Programs at California State University, Sacramento, begins formulating the next edition as soon as the previous addition is completed; continuing its ongoing cycle of assessment, review, modification, expansion, deletions, and corrections, to keep abreast of and implement new advancements driven by the wastewater collection profession (Figure 15).

References

ABC, “Wastewater Collection System Personnel Examination Questions, Harris Seidel, ABC, Executive Secretary, Ames, IA, 1980

ASTM F2550-06, Standard Practice for Locating Leaks in Sewer Pipes Using Electro Scan - the Variation of Electric Current Flow Through the Pipe Wall. ASTM Committee F36 on Technology and Underground Utilities and is the direct responsibility of Subcommittee F36.20 on Inspection and Renewal of Water and Wastewater Infrastructure, 2006

ASTM F2550-13, Standard Practice for Locating Leaks in Sewer Pipes By Measuring the Variation of Electric Current Flow Through the Pipe Wall, ASTM Committee F36 on Technology and Underground Utilities and is the direct responsibility of Subcommittee F36.20 on Inspection and Renewal of Water and Wastewater Infrastructure, 2013


Wastewater Collection System Operator Certification Studybook, Donald S. Pottle and James Courchaine, Environmental Educational Services, Concord, MA, November 1982.

US EPA Sewer Electro Scan Field Demonstration Revisited, Terry Moy, Charles G. Wilmut, and Robert J. Harris, September 2012.
Multiple Leaks Found in Laboratory Testing and Electro Scanning Inspection, But Missed By CCTV, Sonar, and Laser Inspection.

Electro Scanning Inspection Recommended Instead of CCTV To Certify CIPP Lining & Point Repairs, and Find & Measure Infiltration.

Add Electro Scan to...
- Aries
- Cobra
- Cues
- Envirosight/Ipek
- IBAK
- Rausch
- UEMSI

Smart Sewer Probe
No Defect Coding. No Operator Judgment. No Third Party Data Interpretation.

“Every CCTV truck or van should add Electro Scan to accurately assess pre- and post-rehabilitated sewers. Why would you keep your hammers in one truck and your best screwdriver back in the office if you need both to get it right?”

Chuck Hansen
Founder & Chairman, Electro Scan, Inc.
Former CEO, Hansen Information Technologies

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As featured in Chapter 4, Inspection and Testing Collection Systems
SEVENTH EDITION, VOLUME 1, OPERATION AND MAINTENANCE OF WASTEWATER COLLECTION SYSTEMS

U.S. Patent # 9143740