VOLUME 2

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THE BOTANY ROCKDALE SEWAGE FARM

A CASE STUDY IN URBAN ARCHAEOLOGY
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Colleen Callaghan
Historical Archaeology Dept.
Sydney University, A17
Sydney N.S.W. Australia 2206

Dear Colleen:

It sounds like you have a unique one-of-a-kind project. You might contact the Environmental Protection Agency in Washington as to their requirements presently and perhaps they would have some report dealing with the evolution of large scale sewage practices. One of the most famous, I suppose, is the example of the Imperial Valley in Southern California, where, I understand, sewage disposal pipes from Los Angeles created great deltas on the desert floor. The pipe heads were moved periodically, but the result was one of the richest agricultural valleys around. I suppose you might write to the Chamber of Commerce at Imperial, California and ask if they know of a history of this sewage disposal history of that area.

A colleague here, Tommy Charles, once worked at such a facility and he says that when the remains from the disposal process were spread onto the fields only three items remained, tomato seeds, cigarette filters and condoms. The fields were literally covered with them. By now they may have developed processes that remove these objects. The tomatoes sprouted in mass fields of tomatoes and people came to collect them to replant.

I know this is not much help, but yours is something of a unique project, at least as far as my experience is concerned.

Good luck with it!

Sincerely,

Stanley South
Archaeologist

THE UNIVERSITY OF SOUTH CAROLINA
SOUTH CAROLINA INSTITUTE OF ARCHAEOLOGY AND ANTHROPOLOGY

March 27, 1991
March 30, 1991

Dr. Colleen Callaghan
Historical Archaeology Department
Sydney University, A17
Sydney, N.S.W.
AUSTRALIA 2206

Dear Dr. Callaghan:

Thank you for your letter of the 15th regarding your work on the 19th-century sewage farm. I must say that I am not precisely certain what a "sewage farm" is, but it sounds intriguing. As such, I will try to answer you as best I can and hope that it is pertinent.

We are beginning a project on sewer development in Peoria in the central part of the state, but our work is really just beginning, so I really do not have any information to send you. However, while I was in Louisiana, I knew of a project on the history of the sewers in New Orleans. At least, I know they were working on the development of the privy system and its relation to certain laws regarding disposal practices. For this information, try: Dr. Charles E. Pearson, 345 S. Waverly Drive, Baton Rouge, LA 70806. He works for a private company called "Coastal Environments." Also, if you haven't already done so, you might try: Dr. Nan A. Rothschild, 60 Bank Street, New York, NY 10014 about her work in New York, or Dr. Pamela Cressey, Alexandria Archaeology, 105 North Union Street, #327, Alexandria, VA 22314. Pam's the head of the Society for Historical Archaeology's "Urban Archaeology Forum" and is one of the most knowledgeable people in the US on urban archaeology. I'm afraid that's about all I can suggest; I hope it helps.

On a more personal note, I would really like to know something about your "Historical Archaeology Department." It sounds like a fantastic idea and I would like to know more about it. We will never be so advanced here in the US to have such a thing; my program is probably as close as we will get. Do you have any information you can send me? Thanks.

Sincerely,

Charles E. Orser, Jr.
Associate Professor of Anthropology and Director

Normal-Bloomington, Illinois
Phone: 309/438-2271

Edwards Hall 111
Normal, Illinois 61761-6901
May 15, 1991

Ms. Colleen Callaghan  
Historical Archaeology Dept.  
Sydney University, A17  
Sydney N.S.W.  
Australia 2206

Dear Ms. Callaghan,

I must begin by apologizing for my delay in responding to your letter. Yours was not a request that I could answer immediately and hence put it away until I could find the time to check resources I could refer to you. I know little about the subject that you are investigating, but did a bit of research. The enclosed brief article was the main result of that initial stab in the literature. I also began quizzing my friends and colleagues on the subject, and was led to a Canadian archaeologist who has been studying in Williamsburg this year. Joe Lash is currently studying privy patterns but indicated that he has had some experience in other kinds of archaeological sites to do with sewage disposal. His address in Canada is below. I will also send him a copy of your letter.

I am sorry I am not able to offer more. Good luck on your project, and let me know if I could be of any other assistance.

Sincerely,

Ann Smart Martin  
Research Fellow  
Dept. of Archaological Research

Joseph Last  
P0 Box 1961  
Cornwall ON Canada  
K67 6N7  
phone: 613-938-1242
May 7, 1991

Ms. Colleen Callaghan
Historical Archaeology Department
Sydney University, A17
Sydney, N.S.W.
Australia 2206

Dear Ms. Callaghan:

Thank you for your kind letter of March 15, 1991, and I'm sorry to say that I am familiar with no historic archaeological research here in the United States which has addressed the large-scale disposal of sewage. Aside from those sources referenced in our 1984 *Historical Archaeology* article, I'm afraid I can be of little help. Good luck with your research.

Sincerely,

JOHN MILNER ASSOCIATES, INC.

Daniel G. Roberts
Vice President and Director
Cultural Resources Department

DGR/bjt
May 30, 1991

Ms. Colleen Callaghan
Historical Archaeology Department
Sydney University, A17
Sydney N.S.W. Australia 2206

Dear Ms. Callaghan:

Thank you for your very interesting letter about your sewage farm research. As far as I am aware, there have been no similar studies in the part of the United States. In fact, I have read of any such studies anywhere in this country, although there may well have been some associated with cultural resource management programs.

I am at a loss as to who might be able to provide such information, and I suggest that you send a note of inquiry to The Society for Historical Archaeology Newsletter. The editor is Dr. Norman Barka, Department of Anthropology, College of William and Mary, Williamsburg, Virginia. Good luck.

Sincerely,

Kathleen A. Deagan
Curator

KAD/drs
Ms. Colleen Callaghan  
Centre for Historical Archaeology  
Sydney University, A17  
Parramatta Road  
Camperdown, Sydney  
Australia 2050  

Dear Ms. Callaghan:  

VANCOUVER'S EARLY SEWERAGE SYSTEM  

Here is an outline of our early sewerage system as you requested for your thesis.  

Prior to 1888, there were no sewers in Vancouver. Sanitary sewage was contained in outhouses and septic tanks, with runoff being conveyed to watercourses/receiving waters via drainage ditches. Vancouver developed rapidly after incorporation in 1886, prompting concerns regarding public health. The City began to lay combination sewers in 1888, which was a full year before the water supply system needed to flush the sewers was in place.  

During the late 1800's/very early 1900's, there were no reports or standards for design and construction of the sewers. The primary objective was to simply transport the sewage away from where people lived and discharge it directly to the nearest body of water. Unlike Sydney, we have no record of sewage farming ever being used in the City. At the turn of the century, residents of the "False Creek" area complained of deteriorating water quality, probably due to the lack of water movement.  

A sewerage committee in 1911 engaged the services of Mr. R.S. Lea, a consulting engineer from Montreal, Canada to propose a scheme for the disposal of both sanitary sewage and storm runoff in the area. The Lea Report is 84 pages long and on file at City Hall. The underlying concept of the Lea Report was to dispose of sanitary sewage and surface runoff by direct discharge at suitable outfall points into Burrard Inlet, English Bay, and the Fraser River. The Lea Report formed the basis for the design of sewerage and drainage facilities for the Burrard Peninsula until we started primary treatment to sewage in the 1950's.  

I have included a few pages from the 1913 Lea Report on sewage farming. I hope this information is of assistance to you and good luck with your thesis.  

Yours truly,  

[Signature]  

Sewers Engineer  

CRT/gf  
Encl.  
E61292-7  
PRINTED ON RECYCLED PAPER
The necessity of keeping the sewage in a fresh state limits the duration of the sedimentation period, and about one-third of the organic matter, together with about the same proportion of bacteria can be removed by plain sedimentation. The removal of the heavier organic solids simplifies the problem of disposal with respect to the formation of troublesome sludge deposits, and also to a less extent with respect to the degree of dilution required for the satisfactory assimilation of the sewage. When the available quantity of diluting water is incapable of effecting this latter purpose, the load on the water must be lightened by the oxidation of the organic matter in the subsided sewage, preliminary to its final discharge. That is to say, the sewage must be submitted to a process of so-called purification.

Broad Irrigation or sewage farming was one of the earliest methods adopted for this purpose. It originated and has had its most extensive application in England. Later, an allied method, known as "Intermittent Filtration", came into practice in the New England States. The natural sandy formation there permits satisfactory treatment at a higher rate than is favorable for the cultivation of most crops.

Both of these methods have been continued where large areas of suitable land are available. Still later, Contact Beds, and more recently, Sprinkling Filters, were developed in England and have come into
general recognition. The filtering medium in both types consists of some such easily procurable material as broken stone. Their method of operation, however, is entirely different.

With Contact Beds, the sewage is admitted to the tanks containing the filtering medium, and is retained there for sufficient time to permit the desired sedimentation, bacterial action and oxidation; the sewage is then drained off, and further opportunity is afforded for the digestion of the retained solids, by allowing the tank to remain empty for a time, before re-charging. Where the degree of purification requires it the whole process is repeated on secondary beds. The effluent is acceptably clear, and, more important still, is oxidized to a stable condition. The bacteria also are largely reduced.

In sprinkling filters, the sewage is sprayed over a coarser medium, through which it freely percolates. The effluent from these filters is oxidized to a condition of stability, and the bacteria largely reduced. The effluent is not clear, but the solids still in suspension are relatively stable and readily subside with a few hours' sedimentation. Preliminary clarification is favorable to the successful and economical operation of Contact Beds, Sprinkling Filters, and to a less extent intermittent sand filters.

Sprinkling Filters and Contact Beds have
largely superseded the earlier land treatment methods, chiefly because the comparatively small area required has made their general adoption possible. Sprinkling Filters are a marked improvement over Contact Beds in this respect.

The very great disparity in the areas it is usually found necessary to provide for the various methods of Purification can be fairly represented by stating that the sewage which would require 200 acres for its disposal by Broad Irrigation can be treated on 25 acres by Intermittent Filtration, on 2 to 3 acres in Contact Beds, and on one acre of Sprinkling Filters.

With respect to the character of the effluent produced, the modern methods do not compare with the earlier land treatments. The effluent from a well conducted sewage farm approximates the quality of a good drinking water. The effluent from Intermittent Filters is not quite so good, although all but one or two percent of the bacteria are removed, and in appearance it is all that can be desired.

Contact Beds and Sprinkling Filters, in conjunction with proper facilities for screening and subsidence, can nevertheless produce a stable effluent of satisfactory appearance, that is to say, there is little likelihood of it becoming offensive to the senses, and it can be safely discharged into a harbor or stream, without danger of creating a nuisance in either the aesthetic
or commercial sense.

Very often, however, bacterial contamination is the chief objection, and at times the sole objection to the discharge of crude sewage into natural waters. It has already been pointed out that sedimentation and the different processes of Purification are effective to a varying degree in removing the bacteria. Moreover, subsided sewage may be sterilized by treatment with some such disinfectant as "Hypochlorite of Lime". This treatment may be applied, either in conjunction with, or without, any of the processes of purification, according as it may be necessary or expedient from economical reasons to do so. Where the sewage is charged with trade wastes, more elaborate clarification plants or special processes may be required for its treatment.

In short, it is possible, by artificial treatment of sewage, to effect almost any desired degree of purification. It is largely a question of expense.

Apart from the initial cost of the works, their attention to successful operation requires more intelligent and entailed a greater expense, the further the purification is carried. Moreover, the operation of a disposal plant in the vicinity of human habitations is subject, usually to sentimental, and occasionally to real objections.

Where inland and tidal waters are available for the convenient disposal of sewage by dilution, obviously
Ms. Colleen Callaghan  
Centre for Historical Archaeology  
Sydney University, A17,  
Parramatta Road  
Camperdown, Sydney, Australia 2050

Dear Ms. Callaghan:

Thank you for your interesting letter. My staff has gathered a number of documents which will hopefully be of assistance to you in your research.

From what I understand, your thesis centers on the origins and construction of metropolitan Sydney’s wastewater treatment system during the nineteenth century. The history of municipal wastewater construction by the City of San Francisco (Enclosure #1) may offer some parallels. Construction of approximately 250 miles of sewer was completed between 1850 and 1899, with discharge running either directly into the San Francisco Bay or the Pacific Ocean. Documentation regarding wastewater construction and planning during this period is limited, however, since most of those documents were destroyed in the fire occurring after the 1906 earthquake. As an alternative, you might consider contacting the Public Works Departments of other cities.

In response to your professor’s claim regarding the Imperial Valley, let me clarify that California’s Imperial Valley is irrigated with freshwater diverted from the Colorado River (see Enclosure #2). However, in the interest of water conservation, California has embarked on a number of projects to assess the feasibility and safety of using reclaimed wastewater and/or sludge for a variety of uses. Enclosure #3a describes such a project recently completed by the City of Monterey, California, approximately 60 miles south of San Francisco. Enclosure #3b describes a project by the City of Los Angeles to reuse its sludge.
This particular regional office of the U.S. Environmental Protection Agency guides the environmental programs of four states (California, Arizona, Hawaii and Nevada) and the Trust Territories. For more information regarding our region, I've enclosed a list of organizations (Enclosure #4) which may be able to provide more specific guidance as you progress in your research. If I can be of further assistance, please let me know.

Sincerely,

[Signature]

Harry Seraydarian, Director
Water Management Division

Enclosure
Wastewater Collection System
There were many factors contributing to San Francisco’s reputation as a wild town right from the start back in the Gold Rush days. The City grew up fast and furious and the development of the sewer system was no exception.

In 1893, two civil engineers by the name of Grunsky and Marsdon were engaged to create a “Report of the Engineers In Charge To Devise a Sewer System”. Part of their report read: “Evils which are out of sight though creating nuisances of the worst kind exist in the sewers of all parts of the city, due to the defective planning and bad constructive work of the past.”

Their report was not acted upon by the Board of Supervisors. But in 1899, Grunsky and Marsdon were again commissioned for another report. Part of that report read:

“It will suffice to say that for 40 years the sewers have been constructed with an almost complete disregard for the volume of sewage to be disposed of. They do not form a part of a system; there is not even an attempt to effect gradual convergence to main lines...but to cut through each other at intersections.”

The discharges into the Bay and the Pacific Ocean were anything but organized, as described in the report: “...it is to be added that the sewers discharge wherever they happen to reach the waterfront or an open waterway. The foul condition of the Bay frontage is known to everybody.” The open waterway of Channel Street, as a former Health Officer put it in 1874 “…smells to Heaven with a loudness and persistence that the strongest nostrils may not withstand and the disinfectants of a metropolis could not remove”.

Grunsky also noted that “sewage... is being utilized during the spring and summer months for the irrigation of Chinese vegetable gardens located...north of Chestnut Street.”

When the report was released, there were 304 miles of known sewer of which 23 miles were wooden. The rest were brick (105), cement pipe (15), and ironstone (161).
As a matter of policy, the Department of Public Works maintains a large in-house engineering staff. Most of the CSO project was designed by DPW engineers and the on-going rehab and replacement of sewers is handled by the Civil Design Section of the DPW Clean Water Program.

There are 31 engineers, drafters, and support staff in the section which is housed at 1550 Evans Ave.

The engineering group is funded by an annual budget that is used to rehab/replace different parts of the sewer infrastructure, maintain a TV inspection program, and manage a database of sewer maps and information.

The recent addition of the CSO transport and in-line storage facilities pushed the total mileage of 5 foot-or-bigger interceptors to over 60 miles. The largest is 17 feet high by 24 feet wide.

There are 120,000 service laterals.

There are currently 894 miles of sewer in San Francisco's 49 square miles of land area.

The system is 100% combined sanitary and storm, with 25,000 +/- catchbasins for storm debris management.

The last known wooden sewer was replaced in 1985.

The amount of brick sewer has declined from 105 miles at the turn of the century to 70 miles today.
Quote from the 1899 Grunsky report on the sewer system: "...it will be seen that to have a satisfactory sewer system, it is necessary to give considerable attention to its details and to the subsequent maintenance and operation under competent and experienced supervision."

Maintenance of the collection system, except pump stations, is handled by the Sewer Repair Division of the Bureau of Street & Sewer Repair. There are 70 staff members in the division which is housed at 2323 Army St.

The chief responsibilities of Sewer Repair are preventive maintenance of the main sewers and catchbasins, emergency service for service laterals, and excavation/repair of all broken sewers. The division operates two shifts per day, seven days a week and is fully paged through the DPW radio system. The division makes use of the most current technology available in order to control costs.

Sewer personnel are tested and trained in part at the DPW underground and trench shoring training facility located at the maintenance yard. The training facility consists of a full scale but small sewer system that includes 40 feet of 3' x 5' egg-shaped brick sewer, along with three concrete-lined pits for trench shoring instruction.
hen came the morning of April 18th, 1906: the earthquake and fire. The sewers came through in very
good shape. However, the really serious loss came when all of the sewer engineering records went up
in smoke from the fire, as noted in a 1908 report by the City Engineer: "...all the original notes and large
scale maps of existing and proposed sewers were destroyed in April, 1906..."

However, copies of the summary reports of 1893, 1899, and 1903 survived. In addition, Grunsky, Marsdon, and
key members of the City staff also survived. After the fire, a field survey was conducted and the resulting notebooks
are a part of the reference library of today's DPW engineering staff.

In 1908, a sewer system bond issue went to the voters, based on the 1899 plan recommended by Grunsky.
That plan provided for the continued use of combined sanitary-stormwater sewers with disposal of untreated
wastewater through outfalls in the Bay and the Pacific Ocean. This remained the City policy until 1938 when
the first treatment plant went into operation for treat-
ment of all dry weather flow and run-off from light
rainfall. More plants were added and recently a $1.1
billion in-line transport and storage system (along with
secondary treatment) was added, beginning in the mid-
70's. Details of the transport system are described
under a separate cover entitled "Combined Sewer
Overflows".
The drainage pattern of the collection system is divided by a ridgeline running in a north-south pattern through the center of the City. However, the population density is significantly higher on the east side, so there is more call for maintenance services there. Also, the east side portion of the system is older and subject to more rehabilitation efforts.
Sewer systems are by nature quite similar wherever they may be. ("Water goes downhill, etc.") Therefore, it may be worthwhile to bring to your attention some of the aspects of the S.F. collection system that are unique...

Only Manhattan compares to San Francisco in the density of people and underground utilities. As noted above, the city has almost 900 miles of sewer in 49 square miles. This makes the task of maintaining sewer services to the citizenry a daily challenge of no small magnitude. Tunnelling under and around solid banks of utility ducts/vaults is a constant experience for maintenance crews.

In addition, there are a number of "only in San Francisco" challenges such as the presence of sheer cliffs in a downtown environment and the ever-present cable cars that also must be tunnelled under. The engineering staff is a frequent user of advanced technology such as inversion lining to rehab sewers that are impossible to excavate either for technically reasons or due to adverse neighborhood impact.

In the 1893 Grunsky sewer report, there was significant discussion about the waste of taxpayer's money on building 3' x 5' egg-shaped brick sewers where a pipe would have done just as well or better from a hydraulic standpoint. Although not mentioned specifically, the maintenance problems of oversized, low-flow brick sewers was implied.

However, as you may imagine, the amount of access to service laterals afforded by a walkable sewer is unbeatable, so the maintenance crews have mixed opinions about the worth of the "3x5's". They remain an anachronistic remnant of the past with a continuing value for as long as they hold up.

Clean Water Enterprise decided to increase the capacity of San Francisco's combined sewer system by building a series of large underground structures to intercept, temporarily store, then transport rain swollen sewage to upgraded treatment facilities.

New underground structures and tunnels act as a moat, surrounding San Francisco's shoreline, intercepting sewage and urban runoff and preventing the combined flows from spilling into the bay and ocean.

The cost of replacing some 900 miles of combined sewer lines with a separate system for storm and regular sewage would have been too costly and would have left the problem of urban runoff unsolved. The
To report sewer problems or flooded streets, telephone the Department of Public Works Operations Service Center at 695-2020, 24 hrs./day.

For information about sewer service bills, telephone 558-2171.

For information about the Clean Water Program and public tours of the sewer system, telephone 431-9430.
Southeast Water Pollution Control Plant

San Francisco
Sewerage Facilities

The City and County of San Francisco is served by a combined sewer system, which means that stormwater is collected in the same sewer lines as domestic and industrial sewage. There are about 900 miles of sewer lines, including 245 miles built before 1892. Treatment is provided by three water pollution control plants; the first was completed in 1939 and the other two in 1951. From 1951 through 1982, these three plants provided primary treatment (basic settling of sewage solids) to all dry weather flow (39 billion gallons per year or BGY). During wet weather, whenever rainfall reached .02 inch or more per hour, plant treatment capacity was exceeded. Six BGY of stormwater and untreated sewage flowed into San Francisco Bay and the Pacific Ocean at 39 locations. Now, the Southeast Plant (see below) has been expanded to include secondary biological treatment and wet weather overflows are being brought under control by the construction of large transport storage facilities along the ocean and bayside waterfront.

Clean Water Program

The third of the City's Master Plans for Wastewater Management was prepared by the City in 1971. The prior plans were in 1899 and 1935. Construction of the first facilities under the latest plan was started in 1975. The Clean Water Program, a division of the City's Department of Public Works, is in charge of this construction. As each element is brought into service, its operation is taken over by the DPW Bureau of Water Pollution Control.
The cost of constructing the Master Plan was estimated in 1980 to be $2.3 billion. By modifying certain projects, the City was able in 1982 to reduce the overall cost estimate to $1.4 billion. This assumes construction of all five systems shown in the chart above. With completion, an equivalent or better environmental result will be obtained.

In 1982-83, the Bayside Core System - which includes the expanded Southeast Plant - was brought fully into service. The Projects in this $400 million system are depicted in red on the map above. The Bayside System accomplishes 73% of the Master Plan goals.

Construction of the $400 million Westside Core System (green) was begun in 1981. In 1985, the Westside Transport, Westside Pump Station, and Southwest Ocean Outfall was completed and brought into service using the existing Richmond-Sunset Plant in Golden Gate Park.

The $300 million Southeast area improvements (orange) comprises Marine CSO (combined sewer overflow) Facilities, some completed and others scheduled for future construction. On the Bayside, the Yosemite Facilities were completed in summer 1989. Sunnydale Facilities are scheduled for completion in 1991, the Mariposa Facilities in 1992, and Islais Creek Transport/Storage Project in 1996.

Also on the Westside, the Richmond Transport (orange) is scheduled for completion in 1994, and Lake Merced Transport (yellow) is scheduled for construction in 1990. The two systems totaling $100 million will complete protection of the City's Pacific Ocean Shoreline.

To comply with Federal and State Sewage Discharge Requirements for the Westside district of San Francisco, the City plans to start construction of the Oceanside Wastewater Treatment Plant south of the San Francisco Zoo in late 1989. The Oceanside Plant will be a modern facility capable of providing secondary treatment to the Westside sewage flows. The new plant will have a peak treatment capacity of 43 million gallons a day and will be able to remove 90 percent of the pollutants. The treated effluent will be discharged to the Southwest Ocean Outfall which extends 4.5 miles into the Pacific Ocean. Operation of this $200 million system will bring the accomplishment of Master Plan goals to 93%.

The Crosstown Ocean Discharge Alternative is currently under study by the Clean Water Program. This provides the City with the alternative of discharging Bayside effluent into the Pacific Ocean rather than San Francisco Bay.
How the Process Works

Primary treatment is a mechanical process that uses screens, grit channels, and settling tanks to remove sticks, rags, other large materials and settleable solids from the liquid sewage stream. Secondary treatment is a biological process that uses bacteria to break down and remove the remaining suspended and dissolved organic matter in the sewage. The treatment process takes approximately 11 hours from start to finish. A step-by-step description of the methods used at the Southeast Plant follows:

1. **INFLUENT PUMPING** Wastewater from the northern section of the City is pumped to the Southeast Plant via the Northshore and Channel Pump Stations. Flow from the Southeast district is pumped at the lift station located in the Plant's pre-treatment building. The two flows are mixed prior to entering the treatment process.

2. **PRE-CHLORINATION** Sodium hypochlorite (bleach) solution is added to the raw sewage at the pre-treatment building to aid in the control of odors.

3. **SCREENING** Bar racks and screens remove floating trash, rags, sticks, leaves, and other debris that might otherwise clog pumps and pipes. Screenings are collected in hoppers and removed by trucks to a landfill site.

4. **GRIT REMOVAL** As the wastewater enters the grit chambers, its velocity is slowed and, just like a natural stream, gravity causes sand, grit, gravel and other heavy materials to settle out. Screening and grit removal take about 2 1/2 minutes.

5. **PRIMARY SEDIMENTATION** (2.1 hours) After pre-treatment, the wastewater flows to eleven rectangular primary sedimentation tanks. Garbage and scum rise to the top of the tanks and are skimmed off while suspended solids gradually settle to the bottom as raw sludge. This sludge is mechanically collected and pumped to digesters while the liquid portion continues on to the secondary treatment process.
AERATION TANKS (2.3 hours) As the liquid sewage leaves the primary settling tanks, it flows to eight aeration tanks or reactors. There it is mixed under pressure with oxygen and bacteria-laden (activated) sludge. The activated sludge breaks down the organic matter in the sewage stream, which continues on to the secondary clarifiers.

SECONDARY CLARIFICATION (5.7 hours) From the aeration tanks the flow is distributed among 16 circular secondary sedimentation clarifiers, each of which is 120 feet wide and 15 feet deep. Here the activated sludge (bacteria from the aeration tanks) is settled out of the sewage. Some of it is pumped back to the aeration tanks where it is re-used in the biological process by mixing with sewage and ample amounts of oxygen. Excess sludge is pumped to the dissolved air flotation thickener tanks to concentrate the waste solids prior to digestion.

EFFLUENT DISINFECTION (50 minutes) After the flow leaves the clarifiers, sodium hypochlorite (bleach) is added for disinfection. Sodium bisulfite is then added to remove the chlorine residual and neutralize the effluent before it is discharged into San Francisco bay.

SOLIDS TREATMENT The Southeast Plant treats all sewage solids recovered during the primary and secondary processes. Primary sludge is blended with secondary sludge and pumped to the anaerobic digesters. (*Anaerobic* means that these digesters contain bacteria that ferment the solids in the absence of dissolved oxygen, reducing the volume of sludge.) Secondary sludge is concentrated in dissolved air flotation thickener tanks before being anaerobically digested. As part of the bacterial process, methane gas is produced and then burned for plant heat. After anaerobic digestion, the primary and secondary sludges are dewatered by centrifuges. Final disposal of the cake (dewatered solids) produced by this process is currently handled by trucking it to a landfill site in winter and spreading on farmland during summer.
Operational Features

The Southeast Plant was originally a primary treatment facility that provided basic settling of sewage solids as its method of treatment. The Plant had an average dry weather capacity of 30 mgd (millions of gallons per day) and a peak wet weather capacity of 55 mgd. Expansion was begun in 1977 and completed in 1982. Now this modern secondary plant has an average dry weather capacity of 85 mgd. Its peak wet weather capacity is 210 mgd.

Equipment redundancy and overlapping levels of operation (manual, automatic, and computer-based) were built into the Plant and related pump stations so that failure of any component will not interrupt Plant operations critical to meeting final effluent requirements.

A computerized central control system continuously monitors the status of every critical piece of machinery (valves, tanks, pumps). The computer control system also monitors the current status of plant operations such as the rate of flow, temperature, pH, and amount of dissolved oxygen. Each of the Plant’s three control centers is equipped with computer terminals that instantly record any equipment status changes or any changes in rate or type of flow entering the Plant.

Laboratory Facilities

Biological and chemical analyses services are provided in the Bureau’s laboratories. Staff chemists test the wastes being released into the sewer system by large manufacturing and industrial firms and restaurants. Tests are conducted for the presence of heavy metals, grease, oil, toxic chemicals, and a number of other potentially harmful substances. Industrial and commercial establishments are assessed a special fee based upon the volume and toxicity of the flow released into the system for treatment.

A battery of daily tests are also performed on the effluent (treated sewage) being discharged from the Plant into San Francisco bay. The biological and chemical oxygen demand on bay receiving waters is measured, and tests are conducted to determine the presence of coliform bacteria. These tests indicate the effectiveness of treatment facilities in removing pollutants.

Twenty monitoring stations are maintained along the southern bayside shoreline and deep water samples are taken offshore from the Southeast and North Point Plant Outfalls. Laboratory chemists analyze samples from these areas to assess the impact that effluent has on bay water quality and marine plant and animal life. This environmental monitoring program provides city and state water quality specialists with a barometer of San Francisco Bay’s health.

In addition, chemists are monitoring the ocean waters around the discharge point for the Southwest Ocean Outfall, which is 4 1/2 miles offshore from the proposed Oceanside Plant. Staff is building a data base to determine whether effluent discharges have a measurable impact on the ocean’s plant and animal life.
Environmental Benefits

San Francisco bay supports a wide spectrum of uses ranging from vista points, walking and jogging trails, and waterfront shops and restaurants to water contact sports, general boating, sport fishing, shell fishing, commercial shipping and industry. It is a vital regional and national resource.

The single most significant environmental benefit that will be attained by the Master Plan is the provision of secondary treatment to bayside dry weather flows, which has been accomplished by construction of the Southeast Plant. The reason this is the most significant benefit is that dry weather flows are of such great volume and concentration of pollutants. Almost two-thirds of San Francisco's residents and most of its commuters and tourists are found within the two bayside drainage districts that are served by the expanded Southeast Plant. Thirty-one of the City's 39 billion gallons per year of domestic and industrial sewage are therefore collected on the bayside. Secondary treatment removes 90% of the pollutants from that flow, rather than the 50% removed by primary treatment.

A second major environmental benefit that has been realized is the correction of wet weather overflows on the central and north bayside, due to completion of the Bayside Core System. Large transport/storage facilities (concrete tunnels and box sewers ranging from 9 to 20 feet wide and 15 to 45 feet deep) have been constructed from Marina Green on the City's northern waterfront around its perimeter to China Basin and on the southern end near Candlestick Park. These facilities annually capture 50% of the 4 billion gallons per year bayside overflows, or 2 billion gallons per year. Of the remaining 2 billion gallons, 1.1 billion will be captured for treatment once additional transport/storage facilities are constructed in the Islais Creek, the India and South Basin areas.
**Design Criteria**

**Basic Design**
- Average Dry Weather Flow: 85 MGD
- Peak Wet Weather Flow: 210 MGD

**Wastewater Loadings**
- BOD, average concentration: 230 mg/L
- Suspended solids, avg. conc.: 220 mg/L

**Screening**
- Coarse Racks: 2
- Clear Space, inches: 2.5
- Mechanically cleaned bar screens: 5
- Clear spacing, inches: .75

**Grit Chambers**
- Number: 5
- Type: Gravity

**Primary Sedimentation Tanks**
- Number: 11
- Average overflow rate: 1000 gpd/sf

**Oxygen Generation Plant**
- Number: 2
- Type: Cryogenic

**Oxygen Storage Plant**
- Number: 3
- Volume: 30,000 gal

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**Aeration Tanks**
- Number: 8
- Type: 6 stages each
- Volume: 1.05 MGD each

**Secondary Sedimentation Tanks**
- Number: 16
- Average overflow rate: 500 gpd/sf
- Return Activated Sludge Pumping Pumps: 6
  - @10,000 gpm max.

**Waste Activated Sludge Pumping Pumps**
- Number: 2
  - @600 gpm max.

**Waste Activated Sludge Thickening Tanks**
- Number: 5
- Type: Solid bowl
- Average sludge production: 100,000 lb/day (dry)

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**Southeast Water Pollution Control Plant, 750 Phelps Street, San Francisco, CA 94124**

To report sewer problems or flooded streets, telephone the Department of Public Works Operations Service Center at 695-2020 (24 hrs./day)

For information about sewer service bills, telephone 558-2171.

For information about the Clean Water Program and public tours of the sewer system, telephone 431-9430.

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**Board of Supervisors**

- Harry G. Britt (President)
- Angela Alioto
- Jim Gonzalez
- Terence Hallinan
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- Tom Hsieh
- Willie B. Kennedy
- Bill Maher
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Brochure Design by Draftics, Inc., San Francisco, CA

October, 1989
ENCLOSURE #4

1. Regarding San Francisco:

San Francisco Clean Water Program
P.O. Box 360
1550 Evans Avenue
San Francisco, California 94124
Attention: Ms. Michelle Pla

or

The San Francisco Public Library
Civic Center
San Francisco, 94102
Attention: SF History and Archives

2. Regarding California, Historical/Archaeological Sites related to municipal construction:

State Historic Preservation Office
California State Water Resources Control Board
Post Office Box 944212
Sacramento, California 94244-2120
Attention: Mr. Joe Pope

3. Regarding Land Application of Sludge:

University of California at Riverside
Dept. of Soil/Environmental Sciences/Geology 2247
Riverside, California 92521
Attention: Dr. Al Page

or

University of Arizona
Dept. of Soil and Water Science
429 Sharitz Building
Tucson, Arizona 85721
Attention: Ian L. Pepper
BENEFICIAL SEWAGE SLUDGE USE
EPA AWARDS PROGRAM
OPERATING PROJECTS CATEGORY

HYPERION TREATMENT PLANT
SLUDGE MANAGEMENT PROGRAM
OPERATING PROJECTS (1987-1990)

SUBMITTED BY:
City of Los Angeles
Department of Public Works
Bureau of Sanitation
Hyperion Treatment Plant
Sludge Management Unit
12000 Vista Del Mar
Playa Del Rey, CA 90293

CONTACT: Sheila Molyneux
Sludge Management Unit
(213) 648-5360

Enclosure 38
EXECUTIVE SUMMARY

TAKING THE HIGH ROAD: HOW THE CITY OF LOS ANGELES BECAME A BENEFICIAL SLUDGE USER

The City of Los Angeles broke new ground on June 2, 1990, as the amount of sludge beneficially reused surpassed that of sludge that had previously been landfilled. This momentous occasion culminated the efforts of many hard working people who are steadfastly committed to utilizing sludge as a valuable commodity. Efforts over the past few years have demonstrated to the public that sludge is not something to be hidden or ashamed of, but a beneficial product that can be utilized in a variety of ways.

In society, the weakest link of the life cycle, that all things pass through, is what becomes of the material after consumption. Not enough attention has been given to the valuable resources contained in sludge and the vital role its reuse can have in society. Realizing this, the City of Los Angeles with its private and public partners have established a viable program which utilizes this product in an environmentally safe, socially acceptable, and an economically sound manner.

Through land application, chemical treatment, composting, and energy recovery the City uses 100% of its daily production of 1400 wet tons of sludge and by-products. Currently sludge is hauled to a combination of farms in Blythe, CA and Yuma, AZ, and to a local chemical treatment site. An on-site sludge drying and combustion process generates 15,000,000 KWH/month of electricity and 70,000 pounds of steam per hour which equated to over $9 million in revenue. The dynamics of such an extensive on and off-site sludge management program demands a high level of control and reliability while maintaining flexibility and creativity.

Efforts of the Sanitation Divisions of Industrial Waste and Environmental Monitoring in addition to plant personnel already have made sludge a more beneficial and workable product for farmers. By reducing the heavy metal content of influent sewage at the source, City sludge has experienced dramatic reductions of cadmium, arsenic, and nickel among other constituents. This greatly enhances the quantity of applications to land in order for the soil and crops to receive the full benefits of the sludge's contents. Other advantages include increased nutrients to replenish soils that have been depleted from synthetic fertilizers; reduction of chemical pesticides; and water conservation through less need to irrigate.

In the next several months, the City's diversified program will include the City bureaus of Recreation and Parks and Street Maintenance. Their joint participation will allow for City yard trimmings to be delivered to permitted composting operations in
Kern and Riverside Counties while utilizing the compost as fertilizer in local City parks and beautification projects.

Since the City ceased landfilled its sludge on November 1, 1989, thus becoming a 100% beneficial user of sludge, reduction of operational costs have been targeted as a goal for the immediate future. The City and its partners have begun to further develop price rebates, volume discounts, multiple phase contracts, distribution and marketing plans that include sod farming and silviculture. Optimizing loading and hauling operations, and hauling during off peak hours have saved the contractors thousands of hours and the City even more in dollars while benefitting the environment.

As the City continues to perform at peak levels, the public at large can expect to reap the benefits. While refusing to rest on its laurels, the Sludge Management Unit aggressively pursues an intensive public education campaign. Through literature and personal contact, the entire public will soon be exposed to the benefits of sludge and a cleaner and safer environment that it provides.
levels which would be beneficial to the soil and non-food chain crops. Private contractors were solicited and selected to pursue these reuse options with the City.

This effort, combined with pathogen removal in the on-site digestion process, enabled the sludge to be utilized in land application at agronomic rates now limited by nitrogen, not heavy metals, and has resulted in increased crop yields. Utilization of sludge has also led to a decrease in use of synthetic fertilizers and chemical pesticides which are toxic to the soil and much more costly to the farmers.

REUSING IT...

Two months after ocean disposal ended, the City began to chemically treat the sludge at a site located 1/4 mile from the plant. Chemfix Technologies, Inc. handled 200-300 wtpd at a cost of $53 per wet ton. The process involved fixation of the sludge with portland cement and sodium silicate which physically binds the heavy metals constituents to produce a stabilized soil substitute. The material was sold to a local landfill, where with favorable approval, it was used as a daily cover. In December 1989, this contract was replaced by a new one with Solids Treatment Systems (STS), a subsidiary of BKK Corporation, which employs a similar practice at a local landfill, thus reducing the cost by a third to $35 per wet ton. Sludge is mixed with potassium silicate and cement in this project and the end product is a drier soil substitute with lower odor emissions and is used as cover for BKK Landfill in West Covina, CA.

In December of 1988, Ag Tech Company began its innovative approach to land application with both Los Angeles and Yuma, Arizona sludges. Blending the two sludges (20% and 2% solids, respectively) together and then reliquifying to 5% solids, Ag Tech loads a continuous feed tractor that injects the product 8 inches below the Yuma desert surface. The sandy desert soil, which without the addition of significant amounts of organic matter could not be farmed, is then seeded to grow non-food chain crops such as barley, cotton, alfalfa, and sudan grass. Ag Tech sludge fed fields are now producing vegetable seed and decorative flower bulbs which are marketed overseas. Three hundred wet tons per day are hauled 300 miles from both Hyperion and Terminal Island Treatment Plants at a cost of $40 per wet ton.

Expanding the land application options brought Bio Gro Systems, Inc. into the program in June, 1989. With a capacity to haul 1000 wet tons per day on short notice, Bio Gro hauls to Blythe, CA, approximately 225 miles from Hyperion. Local farmers in this area receive sludge that is distributed, surface applied and disked at agronomic rates into their soil to grow alfalfa, barley, and cotton. Many farmers often convey their happiness with receiving such a quality product at no cost to them. The sludge saves them approximately $87 per acre in nutrients that they would have had to otherwise spend for synthetic fertilizers to replenish their depleted soils with. (refer to farmers comments in attachments K and L)
Currently 300-400 wtpd is hauled to Blythe at a cost of $37 per wet ton. Bio Gro and the City were recently granted approval to land apply in Los Angeles County for the first time ever. Bio Gro anticipates hauling 80 tons per day to farms in Antelope Valley near Palmdale at a cost of $28 per wet ton.

The ash, which is the by-product of sludge combusted through HERS, is classified as a designated waste and has been beneficially reused since it was first generated in May, 1988. Hauled to Cyprus Miami Mining Corporation through a contract with Marmac Engineering, approximately 7000 tons of ash over the past two years has been utilized as a substitute fluxing agent. The ash which is stored in on-site hoppers is rewetted to 15% moisture to reduce dusting during loading. Hauling in fully tarped vehicles to the site 360 miles away is done at a cost of approximately $250 per dry ton.

This summer the City will have two composting projects on-line. Sending 100-200 wet tons of sludge to Lost Hills, CA and to Riverside County, the Sludge Management Unit joins efforts with the Solid Waste Recycling Division to co-compost yard trimmings. The resulting product will be marketed with a portion coming back to the City for utilization in local parks and recreational areas. Average costs for these operations will be less than $30 per wet ton to both contractors, San Joaquin Composting and Recyc, Inc.

...IN AN ENVIRONMENTALLY SAFE MANNER

Ensuring that all projects utilizing City sewage sludge comply with all applicable federal, state, and local regulations is the cornerstone of the Sludge Management Program. As part of the Quality Control Program, all private contractors must comply with the California Environmental Quality Act (CEQA) guidelines. To avoid adverse environmental effects, mitigation measures, as outlined in the Final EIR for Off-Site Sludge Transportation and Disposal, as well as mitigation measures imposed by site specification permits, are enforced through contract conditions between the City and the respective contractor. To maintain compliance, the City actively conducts random inspections of routes, reuse facilities, and equipment; samples and analyzes all affected or potentially affected areas, and monitors all applicable regulations and permits for compliance.

CEQA 210816 requires the reporting of all mitigation measures to the certification body, which is the City's Board of Public Works. To comply with this requirement, a Quality Control Inspection Program was created which consisted of inspections of every truck leaving Hyperion, surveillance along both authorized and non-designated routes where the trucks may travel, monthly site inspections of each of the facilities to where the sludge is transported, and routine communication with regulatory agencies to ensure permit compliance is being maintained.
Also crucial to the Quality Control Program is an accident and spill response plan. This document lists the agencies that must be notified when there is a spill, how the spill is to be cleaned up and a spill response form that must be completely filled out. This document also contains the approved truck routes and must be shown upon request to continue to haul City sludge. Additionally, drivers are randomly quizzed on the basic elements of spill response procedures before being able to load sludge or ash. The Quality Control Inspection Program is included as Attachment I.

...IN A SOCIALLY ACCEPTABLE MANNER

In the past year, the City has witnessed an overwhelming demand to know more about the benefits of sludge from local communities, professional groups, wastewater and related industries. City plant personnel have given dozens of presentations on the sludge management program in part to educate the public. Abating people's fears is an essential ingredient for a program that meets the needs of surrounding communities. Most recently, thousands of Los Angelenos learned of the benefits of sludge during Earth Day festivities and L.A. City High School teachers were provided with presentations to assist them in instilling an environmental conscience in future generations. Regular meetings are also held with neighborhood groups as the City works cooperatively to develop literature and public forums.

A vast array of plant and Bureau personnel have also been exposed to the on and off-site programs. Many hours of training wastewater treatment operators and engineers, maintenance staff, truck drivers, designers and construction personnel are spent to develop operating and safety procedures that specifically affect the handling of sludge and their areas of expertise.

Once public acceptance is attained, processing facilities and markets within the City will be more readily supported, enabling the City to move programs closer to the plant site, and thus reducing transporting distances.

...IN A COST EFFECTIVE MANNER

Controlling costs is an area every successful operation targets. The Sludge Management Program aggressively pursues a variety of methods to constantly reduce it's costs. Negotiating price decreases through rebates and volume discounts have saved millions of dollars over the past few years. Bringing reuse sites closer to the L.A. area has also drastically cut costs as transportation related expenses are often the least flexible. Bio Gro will soon land apply in Antelope Valley, CA which is 130 miles closer to the plant or a 57% decrease in total miles driven. Additionally, the City releases RFP's to find other innovative approaches for sludge and ash reuse as latest technologies allow for more efficient operations.
On site, the Sludge Management Unit streamlines the contract hauling operations by requiring truckers to arrive at specific times. The concept of loading windows reduces the amount of time drivers spend out on the road. In 1989, approximately 80% of all trucking occurred during non-peak traffic times. Trucking quotas combined with these windows allowed a 12 minute average loading time at the plant. With a newly installed automated ticketing system, truck loading operators no longer need to manually record loading information. Both drivers and operators have expressed great satisfaction as on-site loading is no longer a time consuming hassle.

Future plans to implement sod farming and silviculture will greatly enhance the City's desire to not only reduce costs but to bring back to the City a product that visibly demonstrates the benefits of the City's sludge.

SUMMARY

Just two and a half years ago, the City of Los Angeles discharged sludge solids to the ocean at a rate of 180 million pounds per year. On November 1, 1987, ocean discharge was ceased and was replaced by on-site energy recovery and landfilling. Two years of efforts to diversify the program led to the cessation of landfilling on November 1, 1989. Now as a 100% beneficial reuser of sludge, the City continues to increase the program's reliability and flexibility, adding additional alternatives that are environmentally safe, socially acceptable, and economically competitive. By taking the high road, the City of Los Angeles endeavors to gain public support and awareness while ensuring the public's health and the quality of life.
When the conquest of the west was under way, the Government at Washing­ton was besieged with all sorts of requests for help to put over different schemes. The steam railroad, a comparatively new invention, was an attrac­tive thing to promote. In response to demands for cooperation, the Congress agreed to pay the bill for surveys of possible road routes to the Pacific Coast. The order was signed by Jefferson Davis, then Secretary of War, under President Pierce’s administration.

A party of Topographical Army Engineers was organized under the di­rection of Lieut. R. S. Williamson in 1853, and was sent west to find the most feasible routes for possible railroads. This party was well equipped. Williamson had as an assistant Lieutenant J. G. Parke.

The party composed of: “One mineralogist and geologist; Dr. William P. Blake; one physician and naturalist; two civil engineers; one draftsman . . . accompanied by a mounted escort of three non-commissioned officers and twenty-five privates.” Four six-mule teams, together with five teamsters and eight helpers, and most important, cooks.

At that time only Warner’s Pass, the Techachapi, Tejon and El Cajon were known, and none of these offered especially easy routes or inviting grades. When the San Gorgonio Pass was discovered, Blake wrote in his Review and History: “Imagine the enthusiasm with which the great unknown break in the mountain range between San Bernardino and San Jacinto was approached by members of the party as we made our way east­ward from the region, then practically unoccupied but now known as Colton and Redlands, and found an easy grade and open country for our train of wagons to the summit, only 2,580 feet above the sea. This pass was evid­ently the true gateway from the interior to the Pacific Ocean.

The discovery of this practical and easy railroad route, determined the construction of a southern railroad and made it necessary to acquire from Mexico the strip of country in Southern Arizona, since known as the Gadsen Purchase.

As the result of these explorations, construction on the railroad of the southern route of Southern Pacific Railroad was begun in 1873. Trains were operated to Colton on July 16, 1875 and to Indio on May 29, 1876. With the completion of the southern route traffic was opened to New Orleans on February 5, 1883.

The building of the railroad was the beginning of a new era in the history of the Salton Basin area, with the railroad playing a vital role in the for­mation of the Salton Sea.

The building of the railroad stimulated great interest in the Colorado Desert and many early writers found it a fascinating subject. Blake wrote:

“The alluvions of the Colorado wherever deposited are known to be ex­tremely fertile and valuable for agriculture. The delta has attracted great attention and is now being rapidly reclaimed for agriculture and settlement. It is reached by the main line of the Southern Pacific Railway and by a branch from it at Imperial Junction (Old Beach) to Imperial and Calexico.

The Coachella Valley (North Imperial) is now attracting the attention of settlers. The village and postoffice is on the railway between Mecca and Indio.”

Blake points out that the name is a corruption, or a modified form, of the Spanish word. In his book he quotes an early writer, James B. Williamson: “This is the world-famed Coachella Valley, yet the name is a misnomer. It was originally Conchilla, and is so named on the maps of the United States Geographical Survey. Conchilla means little shells and the name was given in early days from the fact that the whole valley of the Salton from the Mexican line as far north as Indio was covered with tiny fresh water shells.”

Blake also wrote of the climate stating it was one of great heat, low humidity, long summers, and dry winters. He said that: “Moderate winds blow most of the time in hot weather, and these, together with the unusually low humidity, materially temper the effect of the high temperatures. He pointed out with few exceptions throughout the year, the nights are comfortably cool, the small amount of moisture in the atmos­phere resulting in rapid heating of the air at sunrise and cooling off at sunset. In the spring and early summer winds from the west and south often attain a high velocity for from one to a maximum of four days. They are rarely severe enough to do any damage. The average yearly maximum tempera­tures are between 115° to 120°, and minimum temperatures rarely falling below the freezing point, with an absolute minimum temperature of about 18°. Precipitation is small with the average annual rainfall at Indio a little less than three inches, making irrigation a necessary factor in the develop­ment of the Coachella Valley.

After the Southern Pacific has pushed a track through the length of the Salton Basin connecting Salton Basin with the east, during the 1870's, the area began to grow. California businessmen became interested in furnishing water to this fertile area, which was by then becoming known as a potential Nile Valley.

In 1892, Charles R. Rockwood, an engineer and promoter, rediscovered the Imperial Valley. The idea of its reclamation became an obsession with him. Realizing his own lack of experiences in financing and promoting, he
Wire Ferry Across Colorado River. Courtesy Title Insurance and Trust Co.

associated himself with first one and then another, always seeking to bring into realization his plans for reclamation. His quest was strangely parallel to that of Dr. Wozencraft.

Rockwood followed every clue that looked like it led to money; he crossed the continent time and again, visited Europe, saw the bag of gold at the foot of the rainbow several times only to have it disappear by the breaking out of the Spanish American war, the death of a principal or treachery of friends. He was deserted by friends and backers, laughed at as a dreamer by unyielding bankers in the east and west.

Anthony H. Heber became interested with Rockwood when the California Development Company was organized in 1896. He and Rockwood worked together strenuously for four years attempting to finance the Irrigation scheme. George Chaffey, who had known Dr. Wozencraft, became interested in the company and took over the affairs in 1900.

Lack of funds kept the company from completing its main canal until 1902. Because the main canals had to run through Mexico for several miles, the company had to form a Mexican company and obtain concessions from the Mexican government.

With all the difficulties of the promoters, and the magnitude of the undertaking, it is a miracle that the desert was ever tamed by settlers of that period.

The first three families arriving in Imperial Valley, who helped to begin the digging of the first canal were W. A. Van Horn, his wife and six children; W. F. Gilett, wife and seven children and L. M. Van Horn with four motherless children.

These families had been pioneering in the Salt River Valley in Arizona when they heard of the new development about to start on the Colorado deserts. Deciding that the area offered more promise, they bought household goods, what implements they could carry, including two Fresno scrapers, and several crates of chickens into three wagons. Driving five cows and a bull, they set out on their long journey.

This was in the fall of 1900. The little caravan moved its tedious way down the banks of the Gila River, arriving in Yuma in December. They drove to the banks of the muddy Colorado and wondered how they were to get across. They met two other men and the five of them decided to build a raft, and within a week they made a crude craft that would hold a small load and could be poled across the river to carry their families, teams, wagons and household goods.

Not trusting the raft, Mrs. Gilett rowed a boat and took all the small children and Mrs. Horn across. On one of these trips, Ray Van Horn, a lad of ten, riding his pony, plunged his pony from the raft into the water, tied the end of his lariat to timbers on the rafts and pulled the raft free from a sandbar where it had stuck in the middle of the river.

Safety over the river, the three venturesome families found themselves in Mexico, facing the Mexican custom officials; lists and manifests had been carefully prepared and the officials checked them thoroughly. Everything was all right — but wait!

“Where are the chickens?” asked the officers; but no chickens were on the list. The settlers were compelled to send the chickens back to Yuma, ship them by rail to Flowing Well, and one of the men made a sixty mile trip with a team to get the chickens back to their camp.

The three families went to work for the California Development Company immediately. Gilett hitched his team to a plow and broke the first furrow. Van Horn’s two scrapers were the first of thousands of the Fresno scrapers that were soon turning dirt, building canals and leveling land in the valley.

Mrs. Van Horn and Mrs. Gilett took care of seventeen children, managed the commissary and cooked for thirty-two men for almost a year. Housekeeping was primitive in these days and the principal household utensil was a good, sturdy can opener.

There was no railroad at that time, and freight and express was hauled by wagon from Old Beach located on the main line, which is now the town of Niland. Because of this, nothing perishable could be brought in so the settlers were without milk, butter, eggs, fresh fruit, vegetables or meat.

The hardships these people endured and the primitive conditions of those times are hard for us to conceive today. The following description of one of the valley towns by Tout, is enlightening:

“The town of Imperial, when we came here, consisted of two large tents used for a hotel, one the kitchen and dining room, the other divided into sleeping rooms; and a light frame building that housed the first newspaper and publisher’s family. The first little Christian church was a frame building and was later destroyed by fire.

“The other frame building was a general merchandise store, with a lean-to at the side which was our first bank presided over by Mr. Leroy Holt. There was a shed used as a blacksmith shop and perhaps a dozen tent houses.”
F. C. Farr writes of this same period: "The only women in Imperial and for miles around were the wife of the editor of the paper, Mrs. Frost and Mrs. Holt. There was then no wire communication with the outside world and the mail was often behind time. The people occasionally became hungry and found difficulty in keeping warm, the stovepipe would blow away. When this happened a neighbor would chase the stovepipe on the Holt pony, fearing it might land in the canal and be lost forever.

"Mrs. Holt recalls one Sunday when they had no meal all day, the dust was so thick they could not eat in the tent-house. The children were kept in bed in case the tent was blown over."

But gradually, the picture began to change, 700 miles of canals were completed, placing nearly 77,000 acres of land under cultivation in the Imperial Valley, settlers began to pour into the area.

With artesian wells furnishing water in the Coachella Valley, towns began to flourish. Indio, Coachella and Mecca were important farm centers. The land was sold to eager farmers at auction sales held in tents at the sites of the new farmlands. By 1904, more than 12,000 persons had moved to the desert and the towns of Brawley, Holtville, Heber, and Calexico. With the railroad connecting these towns with the major markets, the area boomed.

The promoters of the canals were widely praised for their foresight and planning. It did not seem to have been realized, at the time, there was any real danger to the Imperial Valley by flood waters from the Colorado. It was known that large quantities of water had been carried through the New and Alamos Rivers into the Salton Sink in 1891, and also by the New River earlier, especially in 1862, but the channels had not eroded to any marked degree at the gathering ground along the Colorado River bank, but had automatically closed. There is no doubt that the promoters had no idea of the risk of floods when they began building the canals.

During these prosperous times, it appeared that the project would grow, but all was not well. Tons of silt were being carried by the river, gradually blocking the main canal. Tests showed that the Colorado carried 10 tons of silt with every acre foot of water. Then in 1904, the canal was blocked and the Imperial Valley was without water.

The mood of the valley changed, and the farmers threatened the promoters with mass retaliation if they did not correct the situation at once. The situation was urgent and something had to be done at once, to save threatened crops, as well as their profitable holdings.

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Water conditions were alarming for the settlers. They worked frantically trying to dredge out the canals and keep ahead of the tons of silt, that the Colorado kept building up. With insufficient equipment, a lack of capital and time to clean the silt from the canals, the ranchers faced ruin. But even with their limited equipment, they still kept fighting.

During this period the California Development Company encountered many difficulties and setbacks. Settlers were plagued with problems over an error in government land surveys, and could not obtain proper financing to improve their properties. The Department of Agriculture published an unfavorable report on the alkalinity of the soil, discouraging sensible people from settling in the area. This warning was repeated again and if the territory had not already been settled in a very large part, it seems certain that the land reclamation would have been deterred for many years. One such statement from a government bulletin read:

"One hundred and twenty-five thousand acres of land have already been taken up by prospective settlers, many of whom talk of planting crops which it will be absolutely useless to attempt their growth . . . No doubt the best thing to do is raise crops such as sugar beet, sorghum, and date palm (if the climate would permit), that are suited to such alkaline conditions, and abandon as worthless the land which contains too much alkali to grow these crops."

When the United States Reclamation Service Act was passed in June, 1902, the crops produced in the Imperial Valley were causing a rapid return of confidence in the region, and more development and settlers came. Water users formed an association to buy the California Development Company, and during these negotiations, the right of the company to use the Colorado River water was challenged. All of these factors weakened the company's financial position.

One of the worst blows to the company was a report made by Director C. D. Wolcott, Director of the U.S. Reclamation Service, to the Secretary of the Interior. In H. T. Colby's book on the Imperial Valley and the Salton Sink, he notes that the director advised that, even if there were not complications because of the unfavorable soil report by the Department of Agriculture that:

"With the present situation of many of the inhabitants of the Imperial Valley, it is a matter of grave doubt whether it was wise to become involved in the situation.

"Much of the land filed on is unsuitable for cultivation owing to the large amount of alkali and other adverse conditions of the soil. The water supply is deficient, owing to poor construction and accidents to the canal system, and although the fall months there has been ample water, it appears that the people will not utilize it, and from the best information are not planting"
crops to any considerable extent. Difficulties of handling the silt are very great, and if the Government is to take up the project, it must make enormous expenditures at once to prevent the country from lapsing into a desert condition."

Because he could not obtain an adjustment of water rights through Congress, Heber had gone to Mexico and obtained a concession from President Diaz, which was ratified by the Mexican Congress on June 7, 1904.

Since Heber could not obtain any help from the United States Government, he conceived the idea of making a cut in the Colorado River over to the government over Colorado River water, and the right to use iters getting help from a foreign government with water, Heber thought dependent on the whims of Washington.

But when Rockwood, the company engineer heard of the plan, he was reluctant to make the cut. Knowing the wily Colorado, he felt it was a danger plan from an engineering standpoint, and he felt that the hazards were too great. However, the temper of the people of the Imperial Valley was growing ugly, and fighting over water was becoming commonplace. Against his better judgment, Rockwood made the cut.

Although Heber felt this was a victory, it proved not to be. The blow which ruined the credit of the California Development Company at that time with Southern California banks and larger financial institutions throughout the country was the announcement by the Secretary of the Interior in 1905, that the Assistant Attorney General had concluded that no law existed whereby it could deal with the problem of carrying water through Mexico.

Such were the conditions in the spring of 1905 when the Colorado went on a rampage, and smashed into the channel, overflowing its banks. Unchecked, the flood waters rushed northward to the Salton basin. Because the Salton Basin was below sea level, and the river higher ground, the settlers realized their danger. They fought frantically to divert the river back to its old course.

The raging New River poured into the valley, a huge waterfall formed where it poured from the cutback into the Basin. The swirling torrents of water had enlarged the channel intake to a width of 1,200 feet, and the water rushed into the Salton Sea.

Rockwood and the company fought frantically to save the Valley and stop the breaks. The river was dynamited to stop the flow of the New River. The water had been turned down the New River to prevent the flooding of Calexico and Mexicali.

The New Liverpool Salt Company filed suit in Riverside County against the California Development Company for $87,000 damages because its salt fields and plant had been inundated by waste water coming through the three intakes, two of which were without gates.

After the first attempt at closure failed, a dredge was moved upstream where a second dam was begun. The current was too swift, however, and this plan was shortly abandoned.
Illustrating the never-say-die spirit of that little band of engineers battling the unprecedented savagery of the river they plunged into the main channel of the river itself and prepared to throw a dam across the channel from the upper end of Disaster Island, that lay in mid-stream, the west bank of the river. An army of workmen filled 30,000 sacks with sand, a pile driver rigged on the edge of the dredge hammered the pile into the muddy river bottom. It was June flood time, however, and the heroic efforts were fruitless.

The fact they had succeeded in throwing a barrier across a channel carrying 2,500 second feet of water was deemed "a most remarkable achievement" by H. T. Cory, in his book on Imperial Valley and the Salton Sea. The only equipment they had at hand was the make-shift pile driver and Fresno scraper teams.

June 17, 1905, Rockwood gave orders to abandon the work, as he realized that nothing could be done until after the summer flood. At this time the river was carrying a flow of 80,700 second feet, and nearly 9,000 second feet were flowing into the Salton Sea. The water was then within 100 feet of the S. P. tracks along the Salton Sea. By the end of June the flow to the Salton Sea had increased to 14,000 second feet and the mouth of the intake had widened from 60 feet to 184 feet. The stream entering this intake was fifteen feet deep and moved at the rate of four miles an hour.

During the spring and summer of 1905, the 10,000 settlers in the Valley watched the filling of the old chain of lakes on the west side with interest and apprehension. The lakes not only filled to the brim but the water backed up and spread out east and west. The flow of the Alamo on the east side carried away the bridges and the Rositas dam. Bridges at Calexico, Silsbee and Brawley went out.

Some ranchers saved their lands by building levees, but many ranchers left the Valley. A cable was strung across the New River with an undertaker’s basket attached. It was operated with a mule, carrying people, barley and animals across the flood waters.

During this period, the Southern Pacific had loaned the California Development Company an initial sum of $200,000 to attempt to stop the raging torrents of the river. Rockwood and his company of engineers tried several plans to stop the raging river, but met with no success. Five attempts were made, and finally it was realized that the job was too big for the California Development Company engineers.

E. Harriman, president of the Southern Pacific, sent one of his best engineers Harry T. Cory, to attempt to mend the disastrous breaks. Cory, facing what seemed an insurmountable task, had to construct spur lines, recruit labor and set up an organization to deal with the problem, as well as ascertain the best method of stopping the break.

Many engineers were pessimistic about Cory’s chances of stopping the Colorado, some felt that it would be better to let the sea take over the valley.

But Cory had his plans well-made and he took on one of the biggest engineering jobs of the century.

One of Cory’s biggest problems was the acute labor shortage on the west coast. The San Francisco area, the same year and rehabilitation work had drawn labor from the area and the rapid growth of Los Angeles had absorbed much labor. The immigration laws prevented the importation of Mexicans, except in a very small way, although the work that had to be done in Mexico could be done by them.

Because of the heat during the summer months, mosquitoes, brush and arrow weed growths were so dense that white men, no matter how well acclimated could not work very hard in cutting them down. Indian labor seemed to be the only answer.

Cory made arrangements with the Indian agent in the area, and as a result that by the time the work was in full swing, practically all the men, women and children in six Indian tribes were on the work — the Pimas, Papagoes, Maricopa, and Yumas from Arizona; and the Cocopahs and Dieguenos, from Mexico. These six tribes fraternized and got along well, in their camp of about two thousand people.

Yuma was a wide-open town at the time and many white floaters drifted in and out, contributing in some measure to solving the labor problem.

The boiling flood waters had cut a gorge more than forty feet deep and nearly a half mile wide. In contrast, the discharge of the river and fallen directly beside the Rockwood Headgate; the receding waters had exposed sandbars on each side of the main channel. When these sandbars had dried sufficiently, teams were used in throwing up an embankment on the line of the diversion dam.

The Indian labor began working on brush jetty to narrow the channel. In a little more than a week, the stream was narrowed to 700 feet, the river gradually falling. Work was then begun on weaving a huge brush mattress, 100 feet wide, and sinking it on the bottom of the river.

A powerful pile driver sank 90 foot long poles in the river break, and as the Indians worked at their frantic task of weaving the huge mattresses of arrow weed, over and under the three-quarter inch cables stretched across the barge, Silas J. Lewis. When a length of mattress equal to the width of the

Southern Pacific Workers Dumping Rock into Colorado River Break. Courtesy Southern Pacific Company
APPENDIX 8:

Additional overseas letters forwarded early in 1991, to which no replies were received, requesting available information concerning archaeological excavations pertaining to sewage farms, sewers, or related subjects:

Mark P. Leone
Department of Anthropology
University of Maryland
College Park, Maryland 20742

Faith Harrington
Department of Archaeology
Boston University
Boston, Mass. 02215

David Barrett
Department of Prehistory & Archaeology
University of Sheffield
Sheffield S10 2Tn

William R. Bowen
Laboratory of Archaeology
Georgia State University
Atlanta, Georgia 30303

Joseph Last
PO Box 1961
Cornwall, Ontario K67 6N7

Dr. Charles E. Pearson
345 S. Waverly Drive
Baton Rouge
LA 70806

Dr. Nan A. Rothschild
60 Bank Street,
New York
NY 100114

Dr. Pamela Cressy
Alexandria Archaeology
105 North Union Street
327, Alexandria
VA 22314
APPENDIX 9:

History of Land Treatment of Sewage in Britain:

The following information has been collated from _The History of Land Treatment in Britain_ by H.H. Stanbridge, in particular from Volume 5 _Land Treatment_. Unless otherwise indicated, the text has not been footnoted.

The deplorable conditions existing in London and the manufacturing towns in England such as the intolerable stenches from accumulations of decomposing refuse; damp, densely packed and overcrowded dwellings; defective ventilation; inadequate and intermittent water supplies; and a general lack of effective sanitation, were brought to the notice of the general public when Edwin Chadwick was asked by the Poor Law Commissioner to inquire into the sanitary conditions of working-class areas in these manufacturing towns. Chadwick's now classic _Report on the Sanitary Conditions of the Labouring Population_, was published in 1842. Chadwick's proposed solution to relieve the insanitary conditions in the manufacturing towns involved the integration of five services:
1. Provision of an adequate and constant supply of water under pressure to every dwelling house.

2. The use of water-closets, in preference to privies, pail closets or earth closets.

3. The discharge of domestic waste waters direct into a sewer, instead of into a cesspool.

4. The sewer to receive, in addition, solid refuse from the streets.

5. The sewer, instead of discharging into a watercourse, to convey the sewage and refuse away from the town to an agricultural area where its manurial value could be utilised.

In order to be effective, this system required larger volumes of water than were available in most towns at that time, and the provision of additional water supplies was needed before it could be introduced on a large scale. This eventual introduction would ultimately lead to gross pollution of rivers, which would not be solved until well into the present century.

As a direct result of Chadwick's findings, a Commission on Health of Towns was appointed in 1843 to inquire further into the matter, and to ascertain whether his proposals were capable of application. In 1857 the National Association for the Promotion of Social Science was formed, and in 1876 the Sanitary Institute was founded.
In the 1840s, James Smith, the manager of a cotton mill in Deanston, Stirlingshire, had found that by fertilising his small farm with the excrement from the privies at the mill he could obtain much higher crop yields. He also advocated the use of steam power for pumping sewage through iron pipes when gravity would not serve the purpose — an idea developed by James Vetch who had designed the sewerage scheme for Leeds.

In 1843 Smith submitted a report to the Commission on Health, recommending steam power for pumping sewage through iron pipes and irrigating the land with sewage by means of hose and jet, with a view to making a profit from the growing of crops. Also influential during these early days, were the views of the German chemist, Justus von Liebig. He opined that green plants were deprived of necessary inorganic elements which were leached from the soil by Britain’s high rainfall, and that eventually the soil would become unproductive for agricultural purposes, unless the manurial value of town sewage was utilised. Both these ideas were enthusiastically adopted by Edwin Chadwick, and were soon officially sanctioned.

The Towns Improvement Clauses Act of 1847 officially recognised two methods for the disposal of sewage: it could be disposed of into a river or the sea; or it could be sold for agricultural purposes thereby making a profit, as long as no nuisance was created. A Commission on Towns Sewage Disposal was appointed in
1857 to inquire into the best mode of distributing town sewage over land, and so applying it to beneficial and profitable uses. It was considered that direct application of sewage in liquid form was the most profitable form of disposal; that the area of land to which the sewage was to be applied should be small relative to the population it served, in order to reduce the possibility of odor nuisance; if necessary a deodorising chemical might be added to the sewage before treatment; that sewage should be applied only to grassland, and full advantage taken of levels to facilitate even distribution of the sewage.

By the mid 1870s, when representatives from Sydney's Health Board were investigating sewage farms as an alternative method for the disposal of part of metropolitan Sydney's sewage, official attitudes in Britain towards land treatment of sewage had changed. In 1870, an booklet entitled *The Sewage Question* assessed land treatment at various sewage-treatment works and farms. The information contained in this booklet was quoted verbatim by the Hon. J.B. Wilson, a member of the SC&SS&H Board, during their discussions on the subject. Sewage farms, if properly conducted, were considered the best method of disposing of water-carried sewage. The manurial value of sewage resided mostly in the solids, and that precipitation by chemicals assisted the settlement of solids, and added to their manurial value before application to land by broad irrigation. It had been established that distribution of sewage over large areas of land
did not constitute a danger to health, as had been originally feared. However, it was gradually becoming recognised that the ideal of the profitable utilisation of sewage was not practicable, and that where this was attempted a conflict of interests arose, in that treatment of sewage suffered, and pollution resulted. With the removal of the profit motive in dealing with sewage, the emphasis was changing from utilisation to pollution prevention.

In 1874, the Second Commission on Rivers Pollution published the factors to be taken into consideration when laying out a farm for irrigation and filtration. Some of the more pertinent factors were, that the land should be at least 1.6 km from the town; free from any liability to flooding; located if possible so that sewage could be conveyed to it by gravity; there must always be a sufficient area available for receiving the sewage; that the area should be not less than 0.27 hectares per 100 persons served. This calculates to 54ha (133 acres) for 20,000 people, which was the estimated population of the southern slopes of Sydney. The Botany Sewage Farm, which received the sewage from the southern slopes, was 123 ha (309 acres) in size.

In 1876 the Society of Arts Conference on Health and Sewage of Towns in *The Health and Sewage of Towns* summarised land treatment in use at the time, and stressed that a profit should not be
looked for by the locality establishing the sewage farm, and only a moderate one by the farmer.

Dantzic Irrigation Works:
The SC&SS&H Board were impressed with the results of the Dantzic Irrigation Works, where raw sea sand was irrigated by sewage. This had commenced in 1871 on about one hectare of land, part of which was cultivated, the other being useless sandy soil. By 1874 the area under cultivation had increased to approximately 15 hectares. With continued application of sewage to the land, a considerable depth of compact humus, or vegetable soil, had gradually formed on land that was previously sterile, and the farm had become highly productive, and no less than four to six cuttings of grass were obtained, while the best land in the neighbourhood only yielded two cuttings. The land on which the sewage was utilised was originally so valueless, that it was let at about 5d. an acre (.4 ha) but by 1874 it was rented to a contractor for over 31s.6d. per acre, on a thirty year lease.

Intermittent Downward Filtration:
Following Chadwick’s early experiments with the distribution of sewage over the land by hose and jet, the usual method of
applying sewage to land had been by broad irrigation. This method of land treatment created problems, when combined with the growing of crops. The application of sewage had to be interrupted while the land was being cultivated, and when crops were being planted and harvested.

Intermittent downward filtration had first been developed in Britain by Sir Edward Frankland, and his results had been published in 1870. His scientific experiments on filtration of crude sewage through soil had demonstrated that porosity and fineness of soil particles were more important factors in the filtering process, than the chemical composition of the soil. To keep the soil aerated and prevent clogging, he suggested levelling the surface of the land and underdraining it at a depth of 1.83 m., as well he recommended that the area of land be divided into four plots of equal area, and dosed in rotation, with sewage being applied for 6 hours out of the 24. This method used a much smaller amount of land that was formerly thought possible.

Further modifications to this system were made by J. Bailey-Denton, a land engineer, who proposed laying out the land in a series of ridges and furrows, with the sewage flowing along the furrows, and crops being grown on the ridges, thus allowing cropping and sewage treatment to be combined. Following these
developments, a number of authorities in Britain began to lay out land for treatment of sewage using intermittent downward filtration, although in most cases this was combined with broad irrigation.

Birmingham Corporation:

During the 1870s and 1880s, this city acquired the international reputation of being the best-governed city in the world, and interest in Birmingham's civic achievement drew people from all parts of the world, including Sydney, to report on what they saw there. Civic pride was the driving force of a whole civic philosophy, known then and since as the 'civic gospel', and it was sewage which had given the makers of this civic gospel their greatest opportunity.  

The Corporation of Birmingham had commenced land treatment of sewage in the Tame Valley in 1866, on approximately 59 ha of land. In 1870 a special Sewage Inquiry Committee was appointed to enquire into "...the best mode of disposing of or dealing with the sewage of the Borough". One answer to the sewage question was to dispose of 14,000 open middens and ashpits which drained directly into the sewers, and within eight years more than 3,000 wells used by 60,000 people were condemned on the grounds of being dangerously contaminated. Also as a result of this inquiry, the land used for sewage treatment was increased to 163.50 ha. The land was underdrained, and broad irrigation was
used on the sloping sides of the valleys, and intermittent downward filtration was used in the valley bottoms. To begin with, suspended solids had been removed from the sewage by sedimentation in two large tanks, then in 1872, two more tanks were constructed, and precipitation with lime was introduced, and the sludge was air-dried in shallow lagoons.
APPENDIX 9

Footnotes

1. Minutes of Evidence Debate on Sewage Farming SC&SS&H Board 1875 p. 142

2. A. Briggs Victorian Cities Oldham Books London 1964 p. 234
APPENDIX 10

Operative dairies in the City of Sydney - 1875
taken from Minutes of the Sydney City & Suburban Sewage & Health Board

Report on the Inspector of Nuisances on the Cow-yards in the City of Sydney:

<table>
<thead>
<tr>
<th>No.</th>
<th>Where situate.</th>
<th>Name of Cow-keeper</th>
<th>No. of Cows kept</th>
<th>Dimensions of Sheds</th>
<th>General Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>183, Liverpool-street</td>
<td>Sarah Horsey</td>
<td>4</td>
<td>23' x 11' 6&quot;</td>
<td>Yard connected with sewer by very disgusting open drain; not flagged; very dirty.</td>
</tr>
<tr>
<td>2</td>
<td>15-17 Francis-street</td>
<td>John Conlon</td>
<td>5</td>
<td>41' x 11' 3&quot;</td>
<td>Connected with sewer; not flagged; very clean.</td>
</tr>
<tr>
<td>3</td>
<td>Smedley-lane</td>
<td>Martin Cleary</td>
<td>8</td>
<td>24' x 9' 8&quot; and 16' x 9'</td>
<td>Connected with sewer; remarkably clean; flagged.</td>
</tr>
<tr>
<td>4</td>
<td>47, Riley-street</td>
<td>John Bisgrove</td>
<td>5</td>
<td>22' x 7&quot;</td>
<td>Connected with sewer; clean; rubble stones.</td>
</tr>
<tr>
<td>5</td>
<td>104, Woolloomooloo-street</td>
<td>Susan O’Heir</td>
<td>6</td>
<td>30' x 12'</td>
<td>No drainage; dirty; not flagged. 24 cows in adjoining paddock.</td>
</tr>
<tr>
<td>6</td>
<td>Best-street</td>
<td>Margaret O’Brien</td>
<td>2</td>
<td>24' x 7' 9&quot;</td>
<td>Connected with sewer; clean and pitched.</td>
</tr>
<tr>
<td>7</td>
<td>76, Judge-street</td>
<td>Patk. McMahon</td>
<td>12</td>
<td>40' x 10' 6&quot; and 11' x 13'</td>
<td>Open drain to sewer; not flagged. Large paddock facing Dowling-street.</td>
</tr>
<tr>
<td>8</td>
<td>20, Judge-street</td>
<td>Mrs. Burns</td>
<td>2</td>
<td>13' x 9' 6&quot;</td>
<td>Connected with sewer; clean; bricked.</td>
</tr>
<tr>
<td>9</td>
<td>94, Bourke-street</td>
<td>Patk. Clancy</td>
<td>3</td>
<td>13' 9' x 9'</td>
<td>Connected with sewer; clean; bricked.</td>
</tr>
<tr>
<td>10</td>
<td>9, Charles-street</td>
<td>Sarah Mahony</td>
<td>4</td>
<td>16' x 9'</td>
<td>Drains into back lane; clean.</td>
</tr>
</tbody>
</table>

N.B. Apart from being an indicator to the generally parlous sanitary conditions in the city of Sydney in 1875, this list of dairies/cow yards is included, not so much for its relevance to this particular thesis, but because the information incorporated within it e.g. specific locations, areas flagged or bricked, early forms of drains etc., is of particular value to the historical archaeologist vis a vis urban archaeology.
<table>
<thead>
<tr>
<th>No.</th>
<th>Where Situate</th>
<th>Name of Cowkeeper</th>
<th>No. of Cows kept</th>
<th>Dimensions of Sheds</th>
<th>General Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>120, Bourke-street</td>
<td>Mrs. Spooner</td>
<td>1</td>
<td>8' x 6'</td>
<td>No drainage; clean; Connected with sewer; clean; flagged.</td>
</tr>
<tr>
<td>12</td>
<td>90, Palmer-street</td>
<td>J. O'Grady</td>
<td>10</td>
<td>20' x 10'</td>
<td>Connected with sewer; clean; flagged.</td>
</tr>
<tr>
<td>13</td>
<td>Chapel-lane</td>
<td>Mr. Land</td>
<td>18</td>
<td>30' x 10'</td>
<td>Connected with sewer; clean; flagged.</td>
</tr>
<tr>
<td>14</td>
<td>294, Liverpool-street</td>
<td>Wm. Bromley</td>
<td>9</td>
<td>40' x 9'</td>
<td>No drainage; clean.</td>
</tr>
<tr>
<td>15</td>
<td>Liverpool-street</td>
<td>Alex. Kennedy</td>
<td>5</td>
<td>14' x 10'</td>
<td>Connected with sewer; clean.</td>
</tr>
<tr>
<td>16</td>
<td>82, Burton-street</td>
<td>Denis Hegarty</td>
<td>5</td>
<td>8' x 6'</td>
<td>Cow paddock, with several people's cows.</td>
</tr>
<tr>
<td>17</td>
<td>Forbes, Burton, and another street</td>
<td></td>
<td></td>
<td></td>
<td>Cow paddock, with several people's cows.</td>
</tr>
<tr>
<td>18</td>
<td>Forbes, Liverpool, and Mr. Jonas Ray's farm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>250, Victoria-street</td>
<td>James Fleming</td>
<td>8</td>
<td>15' x 10', 14' x 10', 20' x 10', and 9' x 9'</td>
<td>No drainage; clean; Connected with sewer; clean.</td>
</tr>
<tr>
<td>20</td>
<td>Burton-street</td>
<td>Patk. Lindigian</td>
<td>4</td>
<td>34' x 11'</td>
<td>Very dirty; no drainage; cows allowed to wander outside; no sewer.</td>
</tr>
<tr>
<td>21</td>
<td>West-street</td>
<td>Martin McCarthy</td>
<td>8</td>
<td>20' x 8', and 9' x 7'</td>
<td>No drainage; clean.</td>
</tr>
<tr>
<td>22</td>
<td>Barcom-street (east side)</td>
<td>Harley Lavery</td>
<td>10</td>
<td>8' x 9', and 13' x 10'</td>
<td>On boundary of Paddington Municipality; in a very disgraceful state; has been fined several times; no sewer.</td>
</tr>
<tr>
<td>23</td>
<td>485, Liverpool-street</td>
<td>Mrs. B. Gleeson</td>
<td>8</td>
<td>22' x 9'</td>
<td>Drainage into West Creek; not flagged; clean; no sewer.</td>
</tr>
<tr>
<td>24</td>
<td>Selwyn-street</td>
<td>Sarah Evans</td>
<td>10</td>
<td>18' x 9'</td>
<td>Filthy drain into back lane; promises clean; no sewer.</td>
</tr>
<tr>
<td>25</td>
<td>144, Albion-street</td>
<td>John Davison</td>
<td>2</td>
<td>9' x 9'</td>
<td>Very dirty; no drainage; cows allowed to wander outside; no sewer.</td>
</tr>
<tr>
<td>26</td>
<td>106, Little Gipps-street</td>
<td>T. Parcell</td>
<td>9</td>
<td>20' x 9'</td>
<td>Very dirty; no drainage; cows allowed to wander outside; no sewer.</td>
</tr>
<tr>
<td>27</td>
<td>106, Little Gipps-street</td>
<td>J. Coffey</td>
<td>3</td>
<td>13' x 11'</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>113, Little Gipps-street</td>
<td>Norah M'Connell</td>
<td>7</td>
<td>21' x 10'</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Smith and Gipps Streets</td>
<td>George McKay</td>
<td>3</td>
<td>15' x 9'</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Mary-street</td>
<td>Mary Hayes</td>
<td>5</td>
<td>15' x 6'</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>58, Albion-street</td>
<td>Wm. Doyle</td>
<td>4</td>
<td>15' x 9'</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Bourke and Arthur Streets</td>
<td>Mary Toohy</td>
<td>1, and 2 cows</td>
<td>20' x 6' x 8' 11&quot;</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Bourke-street</td>
<td>Corns. Connor</td>
<td>6</td>
<td>20' x 6' x 8' 11&quot;</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>634, Bourke-street</td>
<td>Denis Schweitzer</td>
<td>8</td>
<td>17' x 8'</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>52, High Holborn</td>
<td>Mary M'Namara</td>
<td>4</td>
<td>10' x 9'</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Lansdown-street and High Holborn</td>
<td>Reynolds and Pender</td>
<td>3</td>
<td>22' x 9'</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>188, Devonshire-street</td>
<td>Ann Quintin</td>
<td>8</td>
<td>23' x 10' x 12' 10&quot;</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Cooper and Elizabeth Streets</td>
<td>Martin Haddon</td>
<td>5, and 1 bull</td>
<td>23' x 9'</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Little Elizabeth-street</td>
<td>Margaret Parcell</td>
<td>2</td>
<td>23' x 11'</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>118, Waterloo-street</td>
<td>S. Anderson</td>
<td>5</td>
<td>32' x 10'</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>47, Holt-street</td>
<td>John F. Hodges</td>
<td>1</td>
<td>13' 3&quot; x 9' 3&quot;</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Off Elizabeth-street South.</td>
<td>Robt. M'Neil</td>
<td>3</td>
<td>14' 4&quot; x 9' 7&quot;</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>88, Buckingham-street</td>
<td>Mrs. Carick</td>
<td>3</td>
<td>23' 5&quot; x 10' 6&quot;</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Randle-street (off Devonshire-street.)</td>
<td>Henry Milroy</td>
<td>3</td>
<td>23' x 23'</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Kent and Windmill Streets</td>
<td>John Mulberen</td>
<td>7</td>
<td>45' x 9'</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>52, Bedington-street</td>
<td>John Dwyer</td>
<td>1</td>
<td>19' x 12'</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>135, Princes-street</td>
<td>William Steel</td>
<td>13</td>
<td>20' 10&quot; x 10' 4&quot;</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>176, Cumberland-street</td>
<td>John White</td>
<td>2</td>
<td>39' 6&quot; x 8' 5&quot;</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>143, Cumberland-street</td>
<td>Mary Cox</td>
<td>4</td>
<td>39' 7&quot; x 7' 7&quot;</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>59, Cumberland-street</td>
<td>T. Murray</td>
<td>4</td>
<td>28' 10&quot; x 9' 8&quot;</td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>137, Gloucester-street</td>
<td>Mrs. Tiffin</td>
<td>1</td>
<td>16' 3&quot; x 9' 9&quot;</td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>195, Clarence-street</td>
<td>Thomas Oran</td>
<td>3</td>
<td>19' 5&quot; x 9' 4&quot;</td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>156, Clarence-street</td>
<td>James O'Nara</td>
<td>2</td>
<td>45' 8&quot; x 9' 4&quot;</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>493, Kent-street</td>
<td>John Boyd</td>
<td>2</td>
<td>10' 6&quot; x 11' 10&quot;</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>523, Sussex-street</td>
<td>Jno. P. Hodges</td>
<td>16</td>
<td>28' 3&quot; x 9' 5&quot;, and 9' 9&quot;</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Liverpool and Sussex Streets</td>
<td>William Greely</td>
<td>1</td>
<td>15' x 12'</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Castleleigh-street</td>
<td>Owen Bryan</td>
<td>5</td>
<td>14' 9&quot; x 9' 9&quot;</td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>73, Hunter-street</td>
<td>Henry Clagge</td>
<td>3</td>
<td>12' 2&quot; x 9'</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>80, Hunter-street</td>
<td>Fredk. Randall</td>
<td>3</td>
<td>10' 12&quot;</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>490, Pitt-street</td>
<td>Robert Gauld</td>
<td>2</td>
<td>14' 9&quot; x 9' 9&quot;</td>
<td></td>
</tr>
</tbody>
</table>

**Dimensions of Sheds:**

- 10' 6" x 11' 6"
- 15' 5" x 9' 4"
- 20' 6" x 8', and 9'
- 22' 3" x 9'
- 20' x 8', and 9' x 7'
- 15' x 9'
- 23' x 11'
- 23' x 9'
- 32' x 10' 10"
- 28' x 11' 10"
- 23' x 10', and 9' x 9'
- 20' x 10', and 9' x 9'
- 14' x 10', and 9' x 9'
- 16' 3" x 9' 9"
- 23' 5" x 10' 6"
- 23' 3" x 11'
- 20' 10" x 10' 4"
- 32' x 10' 10"
- 20' 6" x 8' 11"
- 28' x 11'
- 20' 10'
- 15' x 12' 10"
- 18' 6" x 12' 2"
APPENDIX 11

Sewerage Schemes rejected by the SC&SS&H Board:

Liernur system: This method used a complicated, and expensive, pneumatic apparatus to eject sewage, and was considered by the Board to be 'a costly toy';

Precipitation Processes: All methods which used chemicals for precipitation purposes to aid settlement in order to render sewage innocuous, and thus suitable for discharge into a watercourse. In European towns where this system was used on a large scale, investigations showed that the effluent still contained a great part of the organic matter in solution, and great difficulty was experienced in profitably treating the large quantities of residual sludge, even where labour was cheap;

Filtration Processes: These systems attempted to render sewage innocuous by various methods of filtration. They were found to be inapplicable to the sewage of a populous city, especially to Sydney, where the sewage had a number of outfalls mostly in crowded localities;

Conservancy Systems: These aimed to keep all faecal matter entirely out of the sewers, on the grounds that it would be less offensive and dangerous. The Board found in English towns where this system operated, that the refuse from kitchens, laundries, and other sources common to large towns, was quite as offensive after it has become putrescent, and much greater in quantity than that which was discharged from water-closets.

Dry Earth System: Another form of conservancy system which the Board rejected. At the time of the SC&SS&H Board's inquiries, this
system had been in operation in Balmain for about six years, as a voluntary alternative to a cesspit, and the Mayor of Balmain, Henry Perdriau, Esq., and the Council Clerk Mr. James Roby, were called upon to give evidence in May 1875. There were about 330 dry earth closets in the area, and Council contracted a man to remove the matter and to supply the dry earth, who charged nine pence for each room in the house, with a minimum of four rooms and a maximum of ten. They were emptied during the night-time, three times a week from houses with large families, and twice from others. The contents were buried just outside the municipality, on an area of land just given to Council by the Government. The majority of the closets were in the yard, taking the place of cesspits, and only a very few were situated inside houses. These were not patented systems, where the quantity of soil was defined by a self-acting apparatus, instead the soil was put into boxes, and a bucket and scoop was provided. The receptacle in the closet was a specially provided galvanised iron bucket, larger than normal, being 15 inches high and 15 inches across, (30cm x 30cm appx) with a handle on top, and one on the side to draw it out with. One of the major problems with the system was their use as containers for slop water. This made the contents too liquid, and caused the containers to overflow, and to smell. Another problem concerned supplies of the required dry loam, which was further artificially dried in a shed and finely pulverised. The contractor generally collected soil from the surface of the ground wherever he could find it, sometimes off footpaths where
these were not formed, or else made arrangements with the owners of properties. However, as building increased and more land enclosed, difficulties were already being experienced in obtaining a sufficient supply. Although the system was considered a vast improvement over cesspits, the smell of the removed earth was offensive when it passed through the streets, and the SC&SS&H Board considered that such a system would be unmanageable in a large town.
Cesspits

The initial investigations of the SC&S&H Board had disclosed that four-fifths of the early water-closets were liable to be directly connected with the mains, and that the contents of the closet-pans were drawn into the pipes and mains supplying the inhabitants of the city with water. The first of their recommendations resulted in the introduction of the "Water Pollution Prevention Act" on 22nd July, 1875, which required 'that every closet should be connected with a main through a cistern of such construction to secure the water from contamination by any solid, liquid or gaseous matter', and empowered the City Engineer to cut off all direct connections immediately after the passing of the Act.¹

By 1875 just over 9,000 patent water closets had been installed and connected to the 1850s sewerage system, and of this number some 6,000 were disconnected, as they were directly connected to the water main. Not all who had their closets disconnected immediately elected to install cisterns, preferring to flush their closets by bucket. As well, many landlords were not prepared to pay the exorbitant prices charged by mechanics to do the work, and simply cut off the connection and waited until the work could be done more cheaply. This was the case in Rowe Street in the city. Twenty-six closets served the residents in the street, and patent cisterns had been provided to all but four or five. The water had been cut off from these, and they were considered 'very offensive'.²
With regard to cesspits, sub-committees of the SC&SS&H Board personally inspected, and provided detailed accounts of many places where these were badly built and badly maintained. In one narrow, enclosed court which led off a metre wide entrance-way opening off Durand's Alley, which in turn led off Goulburn Street, there were seven one-room hovels, patched with wood and iron, and with very low ceilings. One privy/cesspit served the inhabitants of the court, the dwellings had no ventilation or doorway at the rear, as they were built directly against the high brick walls of Robertson's coach factory which bounded the court on two sides.

The Board considered that the evils of the cesspit system prevailed 'in the most aggravated form' in the Municipality of Waterloo, which was worsened by the fact that it received the drainage from the adjacent, higher Municipality of Redfern. The people in this area were very poor, the soil was moist and sandy, and the open cesspits were generally mere holes in the sand - sometimes not even that - which absorbed the greater part of the faecal matter. When these holes were full they were often filled in and the closet shifted a few yards. Little if any night soil was removed from the district, which was all absorbed or buried in the sand about the houses. It was considered that the soil was gradually becoming contaminated, and if allowed to go unchecked the whole district would become unfit for human habitation. These cess pits were generally adjacent to the wells which supplied the inhabitants with water. 'Between these wells and the faecal deposits a pretty free communication must and as a matter of fact
does often exist', and during wet weather wells and closets ran together with the result that the wells were palpably contaminated. The Registrar General's returns for the area showed an excessive rate of mortality. Municipal authorities had scarcely any power whatever in regulating privies and cesspits. Anyone could construct a cesspit where and how he liked, and quite often pipes were laid for the purpose of carrying the overflow from cesspits into street gutters. There was no effectual remedy for this, and unless a cesspit became a flagrant and intolerable nuisance the authorities were unable to interfere, and then only by the cumbrous process of summoning the owner before the magistrates, 'who fine the offender more or less according to their individual proclivities'.

There was also no Municipal control over the persons who emptied cesspits, who generally charged what they liked and came when they liked. As well there was no recognised place of deposit for the night-soil, and it was known that deposits were often illegally dumped, sometimes close to public roads. Some Councils were indifferent, and sometimes there were conflicts between the business interests of alderman and the interests of the community. In the Municipality of Leichardt, private individuals, including alderman, raised and fattened pigs which were fed on the entrails of sheep and cattle. Twelve to fifteen cart-loads were brought daily from the Glebe Island Abbatoirs to support this enterprise. Despite numerous complaints over the offensive smell from this activity, and the resulting pollution of the streams in the area, Council had failed to appoint an Inspector.
of Nuisances, or to take any preventative action. It was also punishable by fine to slaughter animals in the city, however most city butchers preferred to slaughter lambs and calves on their own premises and preferred to take their chance on being fines, one butcher going so far as to kill a lamb in his bedroom in order to avoid detection.

Disposal of Night Soil:

Over the years many places around the city had been used for the disposal of night soil. In the early years of settlement night soil had been deposited at Farm Cove, later the Domain and Blackwattle Bay were used. In the 1870 about 6" depth of street sweeping and other refuse was spread over Moore Park in front of the Sydney Cricket Ground. As the town population increased and the availability of spare land decreased, there was a corresponding ratio in the increased quantity of night soil, and a decreasing availability of land for final disposal points. By 1876 about eighteen loads of the city's night-soil was being carted each night along Botany Road and deposited in the Botany region, on top of the water pipes from the reservoir.

The quantity of disposable night-soil had increased since the introduction of the 1875 Nuisances Prevention Act. Under this Act noxious privies were an offence, and city dwellers, occupiers or tenants, made written application to the office of the Inspector of Nuisances when they wished to have their privies cleaned out. These applications would be collected each morning by the nightmen, who emptied and cleaned them out and charged according
to the size of the privy. A night-cart was imported from Melbourne and was put into use in the city. Old privies were pulled down, and new ones erected according to a plan recommended by the Inspector of Nuisances for the city, Richard Seymour. In many cases in place of an open hole in the top, a pan was put in which was similar to the pan in a patent closet. The opening at the bottom was 3" wide, and at the top was less than that, to prevent anything large, such as 'bottles, tins, old boots, bones and so on' being dropped inside. They were 'almost without smell' and were considered easy to clean - the only requirement being a piece of rag and some water.

This problem of where to dispose night-soil went beyond the city and involved suburban municipalities as well. All authorities were in agreement on one point, that the ultimate disposal point for human waste must be as far away as possible. However there were twenty-five councils and more than 200 aldermen in the police district of Sydney alone. There was little unanimity among them, and some municipalities had insufficient income to carry out any kind of plan, or even employ one man to supervise the cess pits within their jurisdiction.
1. Twelfth and Final Report SC&SS&H Board 11 May 1877 p.6
2. Minutes of Evidence SC&SS&H Board 1875 p.126-7
3. Second Progress Report SC&SS&H Board 1875 p.4
4. Second Progress Report SC&SS&H Board 1875 p.4
5. Minutes of Evidence SC&SS&H Board p.101
6. Minutes of Evidence SC&SS&H Board p.117
7. Minutes of Evidence SC&SS&H Board p.91
8. Minutes of Evidence SC&SS&H Board p.103