Case Study
Rehabilitating Newark's 19th Century Brick Sewers

Infrastructure systems can last not only for decades, but for centuries – but only if they are well maintained. A plan for rehabilitating a system may encompass many separate projects undertaken over a period of many years. Setting priorities is essential for establishing a cost-effective program aimed at reducing risks and improving performance.

In 1990, the city of Newark, NJ embarked on a 20-year program to inspect and, when necessary, to rehabilitate its 68 miles of brick sewers that were more than a century old. Old sewers are prone to fail, with consequences ranging from the high costs of emergency repairs to disruptions to residents and businesses to collapse of city streets and possible impacts on public health. The program involved six phases. Each phase involved the inspection of a portion of the system, determination of what kinds of repairs were needed, and completion of those repairs. As part of Phase VI some of the sections that were first evaluated in the Phases I and II were re-evaluated.

Table 1 Newark's Six-Phase Program to Rehabilitate its Brick Sewers

Phase	Years	Miles Inspected	Miles Rehabilitated	Cost ($millions)	Major Source of Funds
I	1990-92	13.2	4.2	$11.1	Low interest loans from New Jersey
II	1993-96	12.6	5.5	$12.9	Low interest loans from New Jersey
III & IV	1997-08	21.3	12.1	$24	Grant from U.S. Environmental Protection Agency
V	2008	7.0	5.2	$19	Loan from New Jersey Department of Environmental Protection
VI (Planned)	2009-11	23.8	4.5	$16	Loan from New Jersey Department of Environmental Protection
Total	1990-2011	68	31.5	$83	

The inspection of the sewers produced numerous measures and photographs that documented the condition of the system, and this information was used to grade each segment of the system[1]:

- Grade 1: acceptable.
- Grade 2: minimal potential for short-term collapse, but further degradation is probable.
- Grade 3: collapse is unlikely in the near term, but further deterioration is likely.
- Grade 4: in some locations, collapse is likely in the near future.
- Grade 5: collapse has already occurred or is imminent in some locations.

Priorities for repair also took into consideration the effect of a collapse on the surrounding environment. Three levels of risk were considered:[2]

- Critical A sewers: the cost of failure and the impact of a failure on the surrounding environment would both be great.

[1] The grading technique was based upon *The Sewerage Rehabilitation Manual*, Water Resource Centre, Swindon, UK, 1994 edition. Similar grading techniques have been developed for other kinds of structures, including bridges, highway pavements, and the components of the railway track structure.
[2] The classification technique is described in *Existing Sewer Evaluation and Rehabilitation*, ASCE Press, Reston, VA 1994.

- Critical B sewers: the risk is less, but preventive action would still be cost effective.
- Critical C sewers: failure would have little or no effect unless there were numerous simultaneous failures.

Since all of the brick sewers were located under city streets, they were all considered to be critical A sewers. To manage the rehabilitation work, contracts were let for 18 separate projects, which allowed work to be done in reasonably-sized pieces and staggered over a reasonable time period.

The main benefit of the program is that the city's brick sewers, once renovated, can be expected to perform their services for another hundred years, with much reduced need for future maintenance and emergency repairs and with vastly reduced risks related to public health or collapsed roads. Similar programs have been undertaken in other cities, sometimes combined with efforts to separate rain water from sanitary wastes in order to avoid polluting waterways (Figure 1).

Lessons to be learned from this example include the following:

- A program to upgrade existing infrastructure may require decades to complete.
- Inspection can determine where infrastructure is most in need of rehabilitation.
- Risks associated with failure will vary depending upon the nature of the surrounding areas.
- It will not be necessary to rehabilitate or replace all of the infrastructure, as many sections are likely to be in good condition or in locations where failure will not cause any significant problems.
- Priorities for rehabilitation are highest for portions of the infrastructure that are in the poorest condition and that are located in areas where failure would have the greatest consequences.

Figure 1 Separating Storm Sewers from Regular Sewers on Massachusetts Avenue, Cambridge, MA
In Cambridge and Boston, as in many cities with 19th century sewer systems, when heavy rains over-taxed the system's capacity to handle the combined mixture of sanitary waste and rain water, the noisome excess poured was diverted directly into the nearby rivers or the ocean. As part of various projects aimed at cleaning up the Charles River and Boston Harbor, the two cities worked to develop separate systems for storm water, so that only rain water would be discharged into the waterways.

Resource: Project Evaluation: Essays and Case Studies
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