Sustainable Redevelopment of Sanitary Landfills as Future Golf Courses

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Abstract: Redevelopment of sanitary landfills plays a major role in sustainable development, providing economical, social and environmental benefits. A combination of rising land values, a growing urban population, their needs for recreation activities and mitigation of ecological impacts have encouraged the conversion of completed sanitary landfills into functional golf courses. This study examines the reclamation problems of completed landfill to golf course developments and the possibility of designing a sanitary landfill based on its final use as a golf course. For this aim, a sustainable planning approach for landfill-to-golf course adaptive use projects are discussed, which combines sanitary landfill and golf course design processes and modifies them in a sustainable way.

Introduction

Landfill disposal of waste has been practiced for centuries, but the concept of sanitary land filling has been used for less than 100 years (Graves, 1998, Bagchi, 1994). Basically, sanitary land filling is a method of controlled disposal of refuse on land where waste is isolated from the environment until it is safe. First practices began in Great Britain in the 1910's under the name controlled tipping. The refuse was being dumped between houses and the piles were being covered with street sweepings, rather than taking the refuse to a special location and alternately layering the waste and dirt as in modern sanitary landfills. The Fresno Municipal Sanitary Landfill, opened in Fresno, California in 1937, is considered to have been the first modern sanitary landfill. In Fresno, layers of refuse were deposited in tidelands to produce additional land. It is the first landfill to employ the trench method of disposal and first to utilize compaction (Encyclopædia Britannica, 2009, Melosi, 2000).

There are two types of landfills: Conventional and Bioreactor landfills. Conventionally, they consist of a clay and/or synthetic flexible membrane liner at the base of the landfill to prevent liquid seeping into ground water. Pipes are laid above the bottom liner to capture contaminated water and leachate which is the liquid produced by decomposing organic waste. This liquid is then transported to a wastewater treatment plant for treatment. The gas generated by the breakdown of waste is collected and burned either in flares or in engines that recover useable energy. Bioreactor landfills also work in the same way as conventional landfills but with one major difference. Some of the leachate in bioreactor landfills is recycled through the waste to accelerate the rate of decomposition. This provides more rapid stabilization of waste, controllable and increased short-term gas yields and better leachate control than conventional landfills.

However, both types of landfills pose environmental risks from gas emissions and leachate. Bacteria break down organic matter and methane releases. Leachate sinks into ground and pollutes water. These effects could only be reduced with more recycling, carefully design, better landfill management and awareness of community (WSN Environmental Solutions, 2006). Because of their environmental and visual negativities, the existing image of sanitary landfill by the community is predictably not very good and if simply closed after they filled, they continue to be environmental problems and eyesores, and this situation increases the anticipation of community growth (Thompson, 2008).

On the other hand, communities will need to rely on sanitary landfills because they are still the most logical and economical choice for disposal needs. According to U.S. EPA, in the United States, municipal solid waste generation in 2007 was 765 kg per person per year. While 45 percent of this total discards was either recycled or sent for combustion with energy recovery, the remaining refuse continue to be sent to landfills. In other words, sanitary landfills host 55 percent of the municipal solid waste (EPA, 2008).

Actually no matter how much a community recycles or sends the waste for combustion, a sanitary landfill will always be needed for residue that cannot be handled in any other way.

Redevelopment of Sanitary Landfills

When landfills reach their capacity and are closed, they offer remarkable open-space opportunities. With careful planning, completed landfills could be ultimately utilized for a variety of purposes.

Converting closed landfills into park and recreation areas has been used during the past 50 years. Golf is one of these converted recreation areas and the research showed that first sanitary landfill used for golf courses was built in the early 60s in Carson, CA (Goldsberry, 1996). The importance and acceptance of this phenomenon is growing with the continued expansion of the game and the need to clean up and rehabilitate contaminated sites (EPA, 2003). As the demand for golf continues to grow throughout the world, there is an increasing need to design and construct more golf courses. However, it is difficult to find suitable land for course construction and landfills, with their low value, may be one of the few properties large enough for golf development. So, a combination of rising land values, growing urban population, their need for recreation activities and mitigation of ecological impacts have encouraged people to convert completed sanitary landfills into functional golf courses.

From environmental, economic and social standpoint, landfills and golf courses are a good match. Land improvement and adaptive reuse can be one of the most beneficial aspects of a golf course (Love, 2008). Environmental benefits of this match include many ecological enhancements like remediation of soil or treatment of ground water impacts from waste disposal. A landfill golf course can have positive economic and social impacts, too, by increasing land values in the vicinity and creating jobs. In addition to these benefits, golf courses are one of the few legal land uses for landfill sites. (Kavazanjian, 2007, Gross, 1994).

Although numerous benefits, they are not perfect and have several problems. Four main problems with landfill developments are toxic gases, uneven settling, leachate and drainage (Hazelrigg, 2005). These problems have both environmental and economical disadvantages. Another problem is directly related with designing and construction of golf course. The landfills are not suitable to cut and shape, because of their type of structure (Schmidt, 1991). According to all these problems, golf course development may not be economically feasible and construction costs may be higher than the normal golf course.

In this instance, brief descriptions of two different case studies can help for better understanding the issues associated with redevelopment of sanitary landfills as future golf courses.

Harborside International Golf Center

The site was originally used for disposal of the City of Chicago's municipal solid waste. Later it was used to dispose of incinerator ash and wastewater sludge. In 1991, this 180 hectares solid waste landfill was closed. About 80 hectares of the site was a partially-closed sanitary landfill and a 100 hectares parcel was being used as a construction debris landfill. After its closure, it is decided to convert it into a golf center. The site was near important motorways which carry approximately 300.000 cars per day. The planners anticipated that the combination of good access and a good facility would attract sufficient business to make the golf facility economically viable (EPA, 2003).

Firstly, the old sanitary landfill was capped with a 50 cm-thick layer of impermeable clay - or about 400.000 m³ - dredged from the adjacent Lake Calumet. Capping the landfill to keep the ground from cracking and methane gas from migrating to the surface was an absolute necessity under current regulations (EPA, 2003). Course architect Dick Nugent didn't want tree roots piercing the fill's clay sealant, so he designed an open, sweeping links-style facility with trees that have shallow roots, which are non destructive to the underlying clay cap (Klein, 1998).

Drainage and irrigation systems were also carefully designed to protect the integrity of the clay cap. The golf course architect and the engineer collaborated in the design of an elaborate drainage and collection system that collects all site drainage and stores it at seven dry retention locations within the site, until it releases to a sewage treatment plant for processing (EPA, 2003).

Protecting the existing wetland areas was important, too. A buffer was created at some points between the course and the shoreline, and some portions of the fairway were raised up to 3 meters to allow the incorporation of drainage basins to prevent storm water from flowing into the lake (EPA, 2003).

Another problem was to grow turfgrass on site. Every year 200.000 m³ of sludge had been transported to the site, during the operation period of landfills. Sludge was very organic in nature. However, because of its high rates of fats and salts, it was not by itself, providing a good growing medium. It was drawing water out of plants and was not readily saturating. To solve this problem, a 15-20 cm layer of sand was placed over the fairway. Eventually, with the combination of materials on site and creative design, the grass flourished with virtually no additional fertilizer (EPA, 2003).

At the end, the Golf Center consist a matched pair of 6.500 m, 18-hole championship golf courses and a 24 hectares practice facility, including a Golf Academy. It was built between 1992 and 1995 and the final cost of golf course approached $30 million (EPA, 2003).

Granite Links Golf Club

This site was originally used for disposal of both Milton Town and Quincy City. Most of the land was for the famous granite quarrying industry dating back to the mid 1800's. After abandoning quarries, it was used to dispose of municipal solid waste, construction debris and some industrial and hazardous debris (Hazelrigg, 2005). In 1989, Developers started to think about the reuse of old landfill and they decided to create a recreational complex which includes a championship golf course (Love, 2008). Total area of this complex was 220 hectares, which includes several former landfills and quarries. The golf course incorporated two largest landfills and covered 100 hectares of total (Hazelrigg, 2005).

In the same time, another project was being prepared close to this area: Big Dig, an extensive tunnel project for the relocation of a major highway through the city of Boston. Developers proposed using the material excavated from the tunnel for the closure of the landfill and enhancement of degraded areas of the site (Love, 2008).

Firstly, the landfill had to be closed by being capped with specific layers and depths of material. Fill material from the excavation of the highway tunnel was perhaps the most important item that made the project possible. Both Big Dig Project and Granite Links Landfill Redevelopment Project assisted each other in reaching their own targets. Big Dig saved $40 million by trucking excavate to landfill area rather than to sites farther away and Granite Links Project saved at least the same amount of money by closing the landfill with Big Dig fill (Hazelrigg, 2005).

After the excavated fill was placed and graded to the contours designed for the golf course, it had to be sealed with 25 – 40 cm of clay, placed in 15 cm layers, de-stoned by hand and compacted to eliminate water infiltration into the landfill or allow leachate to escape. Next, a layer of 50 – 100 cm of clean fill material was placed on top of the clay and graded to the design contours. This layer of material was designed to accommodate the sub-surface drainage system, the irrigation and gas recovery system. On top of the clean material, another 15 – 30 cm layer of sandy loam was placed to provide a planting medium for the grasses (Love, 2008).

The recovery system for methane gas from the landfill involved the installation of some 150 wells and a system of blowers and flares for control. Ultimately, this gas will be channeled to drive an engine to generate electricity and is expected to produce for some 20 to 25 years (Love, 2008).

Settlement of the landfill was another concern and required close attention during design of the facilities. Most of the play areas were surcharged with huge stockpiles of excavated fill, whenever possible, as construction progressed (Love, 2008).

After thirteen years, 900,000 truckloads of fill material and a cost more than $110 million, the 27-hole Granite Links Golf Course, athletic fields, rock climbing sites, hiking trails and other amenities provide a successful recreational facility for the visitors (Hazelrigg, 2005). If considered the EPA's assumption about final costs of landfill golf courses, which is between $25-30 million, this cost looks a little bit costly for these kind operations (Walsh, 2003). But it must be considered that the final cost includes the cost of filling and capping the landfill as part of the construction cost where others use previously filled landfills.

A Sustainable Planning Approach for Landfill to Golf Course Development

As is seen, problems encountered in landfill golf courses differ from case to case and solutions depend on how creative the designer is. Just one common problem is about the planning approach. Like above mentioned examples, in most cases, golf courses designed on landfills are afterthought projects and they did not plan before the landfill was designed. However, the best strategy must be to plan for the final use before the landfill is designed (O'Leary, 1992). This will be extremely beneficial from both environmental and economical aspects.

To plan for the final use from the beginning of landfill design and planning, typical sanitary landfill and golf course processes must be combined and both must be modified in a sustainable way.

Inventory and Analysis

First of all, a detailed inventory and analysis should be conducted, as in every project. The desirable design features for the landfill and future golf course should be reflected in the program and site inventory. The program and site inventory provides a means of gathering information about client's needs and site properties. A typical inventory data could be formed with the facts below:

- The wastes to be received

(Total volume, sources and types of wastes, daily quantity estimation, etc)
- The landfill method and materials to be used
  (Type of method, landfill operation time, degree of compaction, filling materials, etc)
- The landfill design
  (Proposed landfill elements, cover thickness, slope, additive cover/waste ratio, etc)
- The golf course design
  (Type of golf course, proposed golf course facilities, etc)
- The specific site information
  (Geology, soil type, topography, existing vegetation, sensitive fields, etc)
- The client's needs and purposes
- Social, political and economic considerations.

After collecting program and site inventory data, they must be analyzed to determine site potential and restrictions for golf course conversion.

The goal of this analysis is to integrate the golf course design elements with the landfill ones, in unison with the site. This analysis requires a team of consultants whose initial goal is to produce a restrictions map and a report of development challenges and opportunities (Hurdzan, 2006).

Design Development

Considering the landfill and golf course projects simultaneously makes the design development process complicated. In the proposed process, the landfill and golf course projects are separated, to create as many alternatives as possible. However, the alternatives should be based on the concepts and site specific conditions noted in the results of analysis report. Because of the special case of sanitary landfills, a design completed without care to the results of analysis report, the course can quickly become a disaster area (Graves, 1998).

The next step is to overlay those alternative designs and to adjust them to develop the best master plan for the landfill-to-golf course project.

During design development process, the course architect must study in cooperation with the consulting engineer of the landfill. The process of coming to the final design solution required patience, much error, a bit more trial and several feedback processes.

Evaluation Process

First step for this process is feasibility study. Normally, feasibility studies are prepared by a team of consultants and this is usually undertaken in cooperation with the golf course architect and other members of analysis and design development processes. In this stage, client's needs and purposes are the most important parameter (Hurdzan, 2006).

Ideally, feasibility studies should include estimation and evaluation of net benefits with alternatives for achieving the defined public goals and, both quantitative and social impact analysis, which is hard to estimate, must be taken into account (Yang, 1993).

After finishing the feasibility study, economic, environmental and social benefits of project will become definite. If the total benefit is less than the total cost, the proposed design will not acceptable and the whole design process should be repeated to change until the benefit is greater than the cost. Here, both the environmental and economic costs have an equal importance. For example, an ideal result in terms of profitability may not be ideal for environment. On the other hand, because of environmental issues and legal restrictions, the total cost of a landfill golf course can be more expensive than a comparable course created on a natural site. Sure, not all golf courses should be low-cost, but cost – benefit balance must be achieved. Otherwise, a loss-making golf course will never be sustainable in terms of both environmental and social responsibility.

Except all these, feasibility study validates the prospective timeline of golf course development. Before moving into construction phase, the data generated by the study could be used to help set milestones and deadlines for golf course development.

Following the feasibility study process, all legal requirements for operating, closing, and then maintaining a landfill must be studied. These requirements are usually strict and they include location restrictions, facility design criteria, closure care requirements, cap zone design criteria, gas and groundwater monitoring requirements (Graves, 1998, Rogoff, 1992).

After the feasibility and all legal requirements are studied, all planning process is complete and it is ready to be realized.

Conclusion

The approach in this paper is based on the belief that if the community needs a landfill, landfill design and its future land use should be considered at the beginning of the development process. With this belief, a sustainable planning approach was developed to pave the way of sustainable redevelopment of sanitary landfills as future golf courses.

This approach consists of three steps:

- Inventory and analysis process
- Design development process
- Evaluation process

After completing every process, a feedback process is also needed. In this way, the planning approach works like a flow chart with a series of accepted or not accepted answers. When all processes are completed with accepted answer, then, our sanitary landfill will be ready to contribute to sustainability by achieving beneficial and profitable future use of the site, as a golf course.

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