City of Los Angeles
Regulatory Affairs Division
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The Terminal Island Renewable Energy (TIRE) project

Outcomes & Results

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Contents

Introduction:

The Terminal Island Renewable Energy (TIRE) project is an innovative method of residual management operated by the City Los Angeles (City) at their Terminal Island Water Reclamation Plant (TIWRP) in San Pedro (see Figure 1 TIWRP Site Map). The TIRE project injects biosolids to a depth of approximately 5300 feet, placing it in the geological subsurface. At this depth the biosolids are injected into the depleted subsurface oil and gas formations where the high heat (temperature) from the earth biodegrades the material. The biosolids are biodegraded to generate methane gas, which can then be used to produce an environmentally safe renewable energy.

Figure 1 TIWRP Site Map

The idea for the TIRE project began to take form in 1999 through the collaboration of Bureau of Sanitation to address 3 issues:

1. The large and increasing amount of biosolids produced by the City
2. The increasing cost of biosolids management through land application
3. The increase in restrictive regulations around land application

The idea (concept or proposal) of injecting biosolids in the deep subsurface was unique and innovative at the time. However it was not an untested or unused idea, the oil industry has used this basic concept for many years prior as a way to dispose of petroleum waste. After adapting pre-existing technology for operations with biosolids the City was able to recognize this technology as a more economic and environmentally beneficial way of managing the City's Biosolids. In 2000 the Board of Public Works approved the Request for Proposal (RFP) and as a result the City executed a contract with Terralog Technologies to demonstrate this new technology-deep well injection of biosolids. GeoMechanics Technologies, previously called Terralog Technologies was contracted for services related to biosolids management. GeoMechanics was tasked with developing and operating a demonstration project (TIRE) which

would allow the City to monitor and evaluate Slurry Fracture Injection. During project development it was estimated that there would be a potential to generate 3.5 megawatts of electricity, enough energy to supply power to 3000 homes, valued at approximately $2.4 million per year. Compared to traditional methods the TIRE project if operated at full capacity would lessen the greenhouse gas emissions by 8,200 tons effectively offsetting the emissions of 14,300 cars. Frequently asked questions and more general information are presented in the TIRE Fact Sheet on page 9 and the TIRE Brochure on page 10.

Outreach:

Leading up to the approval and construction of TIRE the City conducted presentations on TIRE in 2001. During the project development and implementation the request for presentations grew and in 2007 alone 60 presentations were conducted. The outreach program was so successful that during the 2007 Biosolids Program Audit the auditor found that the method of informing the public through the use of the existing communications program was effective and allowed the TIRE project to be accepted and recommended by interested parties, academia, and the public. Specific outcomes are listed in Figure 2 Outreach Efforts.

Figure 2 Outreach Efforts

First 5-year permit:

In August of 2006 the City prepared a Mitigated Negative Declaration (MND) required by California Environmental Quality Act (CEQA) guidelines. In January 2007 the MND was adopted by the City. After the public review process in November 2006 the United States Environmental Protection Agency (US EPA) Underground Injection Control (UIC) permit was approved and the permit was issued. Due to the innovation of the TIRE project the permit would allow for demonstration of the project for 5 years using 3 wells (1 injection, 2 monitoring) with a limit on daily biosolids injection of up to 400 tons. In accordance with the requirements of the EPA permit the City produces weekly reports on the operations of TIRE. In addition to the weekly report the City provides quarterly reports to Bureau management and EPA, detailing operations and results of the project. The report is written through the collaboration of the City and GeoMechanics Technologies. The quarterly reports are also made available to the public and interested parties. The most recent quarterly report was sent to EPA on November 5th 2013.

Construction & Startup:

The ground breaking for TIRE project occurred in April 2007. Three months later in July of 2007 the construction of two of the three permitted wells was completed. The wells SFI#1 and SFI#2 were constructed to protect groundwater and provide protection layers for material leakage. The operations startup phase began in June 2008 with the injection of the following materials on the dates outlined below:

- Brine, July 9, 2008
- Digested Sludge, August 5, 2008
- Wetcake (Biosolids), September 10, 2008

The injectates referred to as bio-slurry listed above were at a rate of 270 gallons per minute (gpm). The bio-slurry material was accepted by the well and injection was considered successful. The first permit milestone to successfully demonstrate biosolids injectivity and review well formation response was completed 35 days ahead of schedule in October of 2008. At the completion of the startup a tentative schedule of biosolids delivery via truck (load) was established at 2 loads a day, 3 days per week. After consistent injection for an extended period of time operations were expanded to 4 loads, 5 days a week in December.

Day-to-Day Operations

At the TIRE project site a mixture of HPE, Brine, Digested Sludge, and Wetcake is injected into the subsurface. Each truck carries 25 tons and a 2 hour processing time has been established.

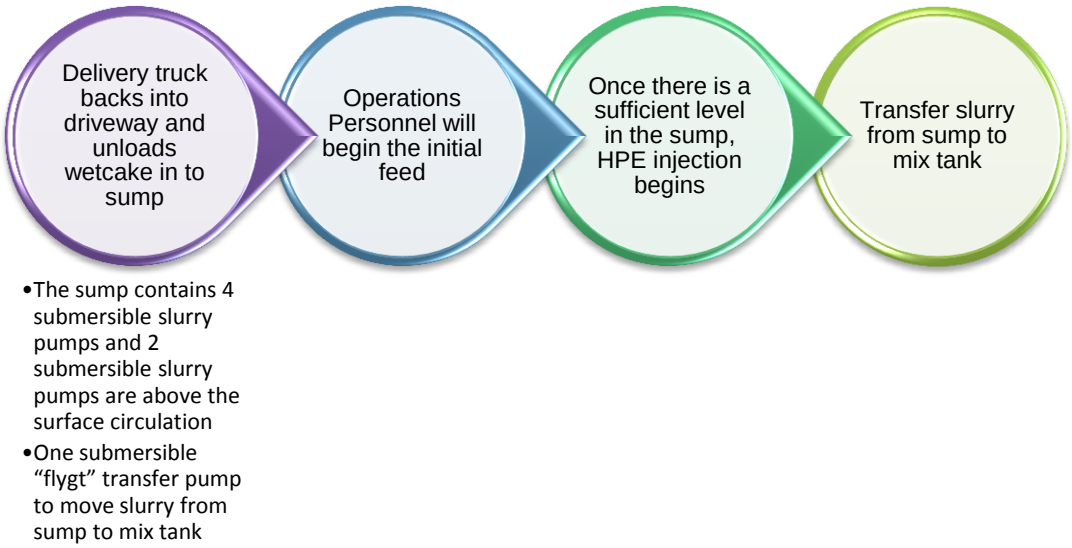


Figure 3 Routine Operations

Over the years injection has been facilitated by several pumps. The current pumping equipment is two 5000 HP PZ-7 electric drive, tri-plex, positive displacement, injection pumps. These pumps were installed in the first quarter of 2010. The average maximum rate of injection is 325gpm, which is equivalent to approximately 8 bpm. To see layout of equipment see Figure 4 TIRE Equipment Overview and Figure 5 Equipment.

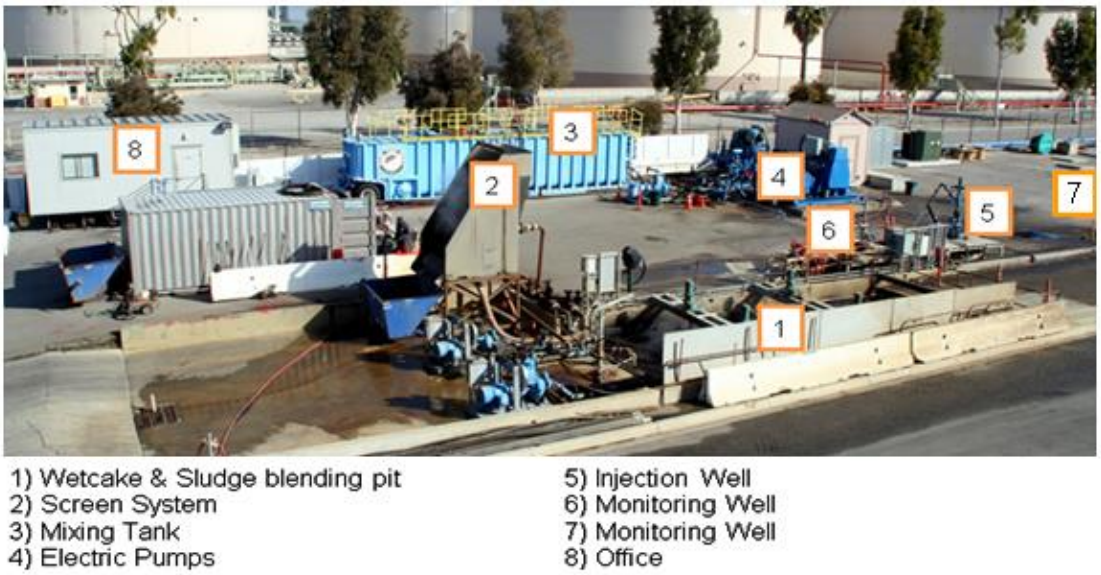


Figure 4 TIRE Equipment Overview

Figure 5 Equipment

Normal operations of receiving 2 wetcake loads from Hyperion Treatment Plant (HTP) began in December 2008. Since 2009 there have been changes in the frequency of that delivery mostly due to equipment changes or construction (see the Timeline at the end of this document). As of July 2012 wetcake deliveries were being made to TIRE 5 days a week with 4 loads Monday thru Thursday and 2 loads on Friday. To date approximately 240 million cumulative gallons have been injected. (To see other cumulative milestones refer to the Timelines starting on page 15)

Drilling a New Well:

Another benefit of drilling wells for the TIRE project has been the investigation of CO_2 sequestration and methane generation in relation to the injection of biosolids. In support of this research the Department of Energy awarded grant funding to specific projects. On July 31, 2009 the City and GeoEnvironment completed the application process and was awarded a grant from DOE to assist with the cost of drilling the third well. The grant was awarded to support research under the heading of "site characterization of promising geological formations for carbon storage." The effective date of the agreement was December 2009. In April 2010 a third well (SFI#3) was drilled and perforated leading to the completion of phase 2 of the project. During the drilling of SFI#3, in April, wetcake deliveries were intermittent and a regular schedule was established again by May. SFI#3 was completed and operational May 2011. Since the TIRE project already had one monitoring well (SFI#1) this additional monitoring well allowed the project to have two data points for analysis to evaluate and confirm well response.

Concentration Tests:

After the completion of the construction of SFI#3 in June 2010 it was determined that the injection capacity for the wells should be increased. In July 2010, a 5 day test was initiated and the wetcake injection was increased from 87-92 tons per day to 143-146 tons per day. At the completion of the trial concentration test the formations were evaluated and results indicated that the tonnage and bio-slurry concentrations did not impact equipment operations or well formation response.

A second concentration test was conducted in February 2011 increasing tonnage to 191 tons for 2 days. The system accepted the additional tonnage without issue however it was decided that the test should be re-run for the benefit of analyzing bottom-hole pressure. In March 2011, operations ran a variation of the test by injecting 6 loads in rapid succession. The second concentration test task was completed successfully and without issue so it was decided that another test should be run for an extended period of time.

Due to operational advancements and improvements in March 2011, almost three years after initial injection TIRE was able to accept biosolids at a rate of 8 loads per day including TIWRP digested sludge. The cumulative injected amount reached a milestone of 100 million gallons.. With the new well operational and a few other updates to the system operations began another concentration test. In June the test ran for 30 working days at which time wetcake was injected 4 days per week at 8 loads a day. To analyze the systems response biosolids deliveries were suspended for 1 week and due to no negative effects from the 30-day test deliveries were resumed. Normal operations continued at 6 loads 5 days per week. In February 2012, another milestone was reached; operations had achieved 150 million cumulative gallons injected. In March 2012, TWAS injection was explored and it was determined that if it became a regular activity a new, larger pump would be required to maintain an adequate flow rate. For more information on changes in load schedule refer to annual timelines starting on page 15

Results/Outcomes

Since the injection operations began in 2008, geological formation response has been consistently good and there has been no impact on public health or the environment. Based on the response both from the public and scientific community the City has elected to continue the TIRE project under a new 5-year permit. To date there have been no odor or noise complaints and no unexplained seismic events associated with the operations of TIRE. The TIRE project has continued to be recognized as one of the most innovative demonstration projects utilizing this method of biosolids beneficial reuse in the country. There have been no negative comments, and the public has continued to express a growing interest in the project. For a comparison of environmental benefits refer to the Comparison of Environmental Benefits chart on page 11. The outcomes have been positive overall, which is an encouraging force behind the City's decision to continue the project. The City has requested to expand the operations to include a second injection well and the positive outcomes have increased EPA's willingness to approve a new permit which would allow for project expansion. This expansion will increase the ability to inject more bio-slurry material and also establish more data points with the use of two monitoring wells and two injection wells.

Second 5-year Permit

In preparation for the expiration of the EPA 5-year permit the City submitted a new UIC permit application in August 2011. In the new permit application the City made the following requests:

- SFI#1 well and SFI#3 well be allowed to alternate or simultaneous injection
- A new SFI#4 well be drilled for monitoring
- Construction of 4 additional replacement wells to mitigate any unforeseen problems
- Drilling SFI#4 well to 7500 feet and potential to deepen the existing wells to 7500 feet

While pending permit review the City also released a Subsequent Negative Declaration (SND) for public review and comment. The SND explored the environmental impacts of constructing SFI#4. The SND was adopted by the City March 2012.

The EPA UIC permit expired in November of 2011, but the EPA has allowed the City to continue operations under the existing 2006 UIC permit pending issuance of a new UIC permit. Since the City submitted the new UIC permit application, discussions are on-going with EPA to issue a new permit to continue demonstrating the project for another 5 years. Permit considerations and modification are being reviewed by the EPA and it is anticipated that EPA will issue the City a new UIC permit by December 2013.

Future Project Goals

Based on the successes of the TIRE project to date the City is interested in continuing operations for an additional 5 years. Under a new approved EPA UIC permit is the hope that by expanding the scope of the current operations that the environmental benefits will be maximized and the City will be able to take full advantage of injecting up to 400 tons of biosolids thus producing enough methane that can be ultimately use to create a renewable energy. The City will continue to provide weekly and quarterly reports on the project to the EPA and conduct outreach events to update the interested parties and the public. The City will continue with the TIRE project as an opportunity to demonstrate the placement of biosolids in deep subsurface is an environmentally sound, safe, and beneficial management option for biosolids that can be replicated world-wide.

TIRE Fact Sheet

CITY OF LOS ANGELES
REGULATORY AFFAIRS DIVISION

Fact Sheet

Biosolids Injection Program-Terminal Island Renewable Energy (TIRE)

The Terminal Island Renewable Energy project, the nations first full scale demonstration project, demonstrates an innovative technology to convert biosolids into clean energy by deep well placement and geothermal biodegradation. The project places biosolids into depleted subsurface geological formations where the earth's high temperature would biodegrade the organic compounds to generate methane gas that can ultimately be used to produce an environmentally safe renewable energy.

Process

- Biosolids are placed 5,300 feet into permeable sandstone
- High temperature (114˚ – 159˚F) of saline environment in deep geologic formation sterilizes the biosolids and allows them to undergo anaerobic biodegradation
- Biosolids are converted to methane, carbon dioxide, and some residual solids
- Carbon dioxide remains dissolved in the brine solution, while high-purity methane migrates up and becomes trapped in a reservoir
- Ultimately methane gas will be recovered to provide a clean renewable energy source

Timeline

- November 2006: 5-year U.S. EPA Class V experimental permit issued
- June 2007: Construction began
- August 2008: First placement of digested organic residuals
- September 2008: First injection of dewatered biosolids (wet cake)
- August 2008-January 2013: Place over 210 million gallons of bio-slurry material
- June 2011: Began monitoring from two monitoring wells
- August 2011: Submitted new permit application to EPA to continue demonstrating existing project
- January 2013: Completed four and half years of operations, averaging 147 tons/day

Environmental Benefits (based on four and half years of biosolids injection: more than 133,000 tons)

- Reduction in air emissions due to decrease in number of trucks transporting biosolids
- Reduction of 13 tons of NO_x and 12 tons of CO from reduced transportation
- More than 16,000 metric tons of carbon dioxide sequestered throughout 4 ½ year demonstration period
- Ultimately provides a clean, renewable energy source of about 3.5 MW (3000 homes)
- Further protection of groundwater

Other Information

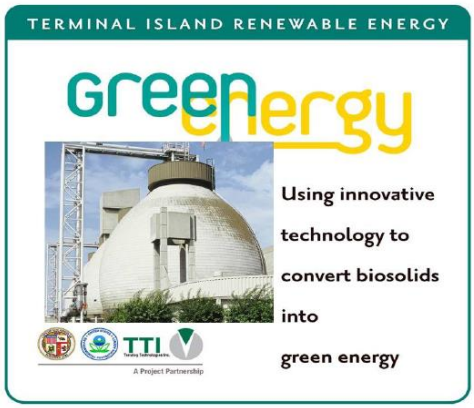
- Winner of Six Awards for Innovation, Research, and Public Outreach
- Capital cost of TIRE project: $8 million
- Nearest residential area is 1.5 miles away
- Reduces biosolids use cost and transportation cost of biosolids by $1.6 million annually
- Extensive use of state of the art monitoring equipment and data collections that monitors pressure, temperature, material amount, and seismicity to ensure protection of the environment and public health.

TIRE briefing sheet-
3/2013

TIRE Brochure

CITY OF LOS ANGELES
SANITATION
DEPARTMENT OF PUBLIC WORKS
Protecting Public Health and the Environment

Biosolids Injection Project



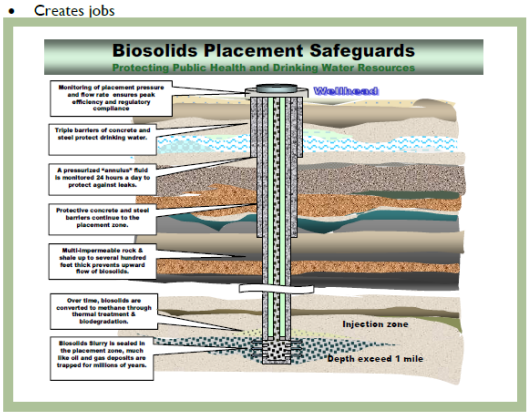
The Terminal Island Renewable Energy Project (TIRE), the nation's first full scale demonstration project, has been in operation for over two years. Biosolids are placed into deep depleted subsurface geological formations where the earth's high temperature biodegrades the organic compounds to generate methane gas that can ultimately be used to produce an environmentally safe renewable energy, while the carbon dioxide is sequestered.

ENVIRONMENTAL BENEFITS

- Will produce methane gas—a renewable energy
- Thermal treatment enhances sterilization of biosolids
- Eliminates more than 547,500 miles of heavy truck traffic per year and associated exhaust emissions, pollutants, odors, and dust
- During 4 years of the 5-year demonstration period the project has sequestered over 15,000 metric tons of CO_2 (a greenhouse gas)
- Placing biosolids in deep subsurface formations using state of the art technology further protects groundwater (see below)
- Reduction of over 12 tons of NO_x and 11.2 tons of carbon monoxide per year from reduced transportation

ECONOMIC IMPACTS

- Reduces transportation costs of biosolids by $1.6 million annually
- Reduces beneficial use cost
- Ultimately provides a clean, renewable energy source
- Creates jobs



Project Partners
The City of Los Angeles • GeoEnvironment Technologies
US Environmental Protection Agency

Update 12/2012

TIRE Project Overview

The City of Los Angeles is demonstrating an innovative technology to convert biosolids into clean energy by deep well placement and geothermal biodegradation. Slurry mixtures of treated, non-hazardous, municipal wastewater residual solids and treated effluent are being placed into depleted geological formations at the Terminal Island Water Reclamation Plant operated by the City of Los Angeles.

At a depth of 5300 ft. material will undergo a natural process of high-temperature anaerobic biodegradation. Retention in the high temperature saline environment of the deep geologic formation will treat and convert the biosolids into methane, carbon dioxide, and non-volatile residual solids. The carbon dioxide will be preferentially dissolved and sequestered in the formation brine, while relatively high purity methane will migrate and become trapped in the reservoir for use as an environmentally safe renewable energy.

Frequently Asked Questions

What are biosolids?
Highly treated organic residuals remaining from wastewater treatment

How many wells have been drilled?
3 (one injection and two monitoring)

How deep are biosolids placed?
5300ft

What range of biosolids is placed per day?
Between 50 and 400 tons

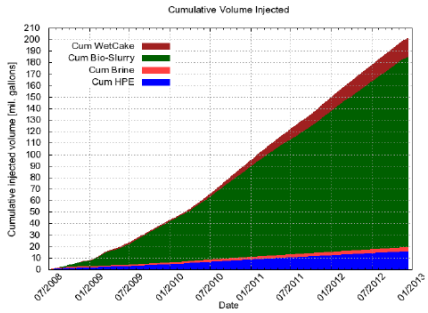
How far is this project from the nearest residential area?
1.5 miles

When will the demonstration phase be completed?
Existing Permit expired November 2011.Project continuing to operate under existing permit pending approval of new EPA permit.

What is the capital cost of the project?
$8 million

How are wells monitored?
Real-time monitoring of pressure, temperature, material amount, and microseismic activity

PROJECT PROGRESS



TIMELINE

- Permit issued in November 2006
- Groundbreaking occurred April 2007 and construction began June 2007
- Completed first two wells - June and July 2007
- Tested placement equipment with effluent and brine - July 2008
- Placed digested organic residuals - August 2008
- Placed dewatered biosolids (Wet Cake) - September 2008
- Completed drilling of third well - June 2010
- Completed four years of biosolids placement operations of at least 150 tons per day - December 2012
- Placed over 200 million gallons of bio-slurry material - July 2008 - December 2012
- Completed first 5-year project demonstration phase and applied for permit renewal for another 5 years - 2011

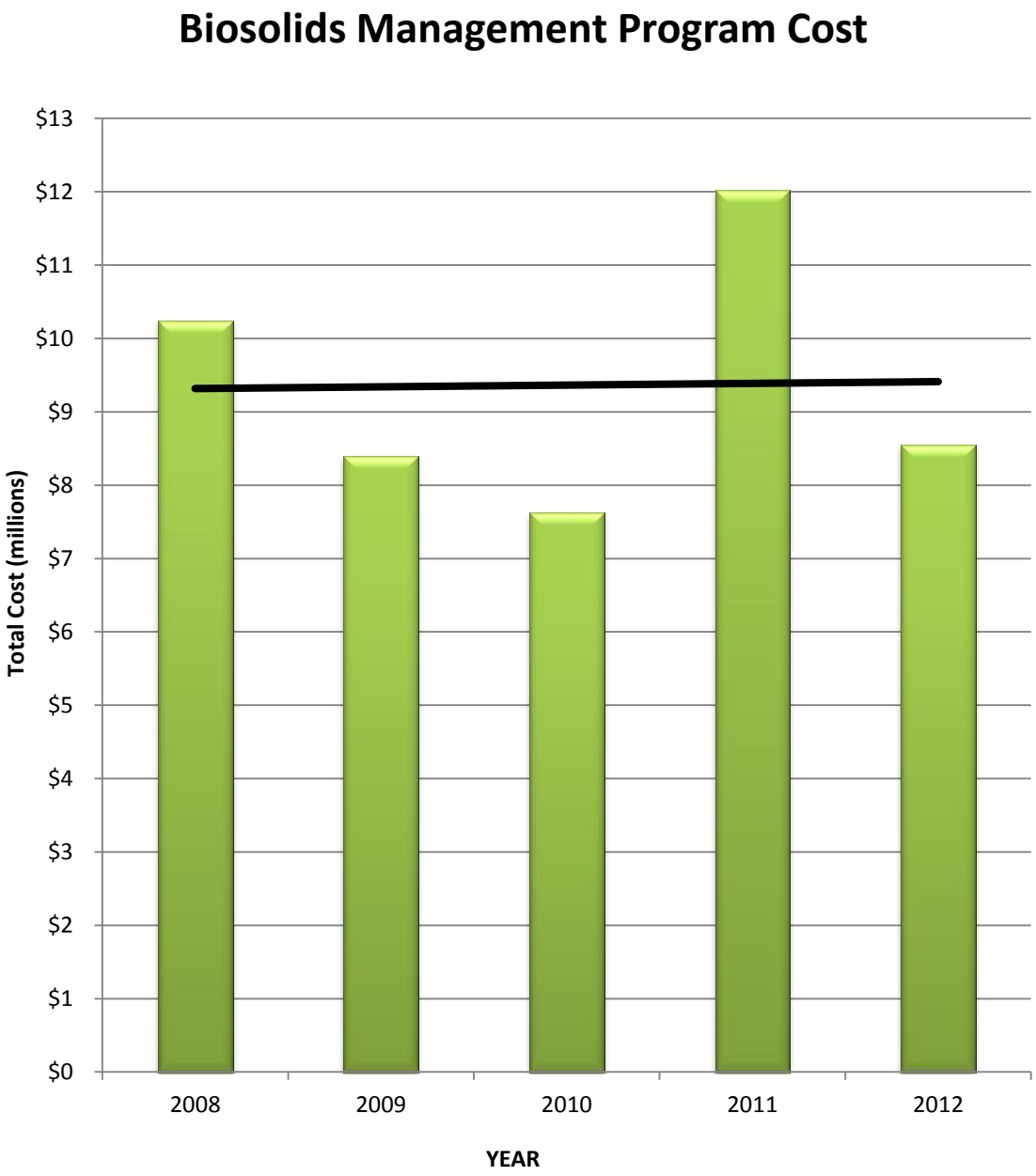
City of Los Angeles Bureau of Sanitation Regulatory Affairs Division
12000 Vista del Mar • Playa del Rey, CA 90293
For more information on this project please call 310-648-5248
www.lacitysan.org/biosolidsems/managing_biosolids/deep_well.htm

Comparison of Environmental Benefits

At the start of the program in 2006 a set of benefits (environmental and economic) were recognized (left column) for the TIRE Project. After 5 years of injection the benefits (right column) recorded are directly related to what was expected

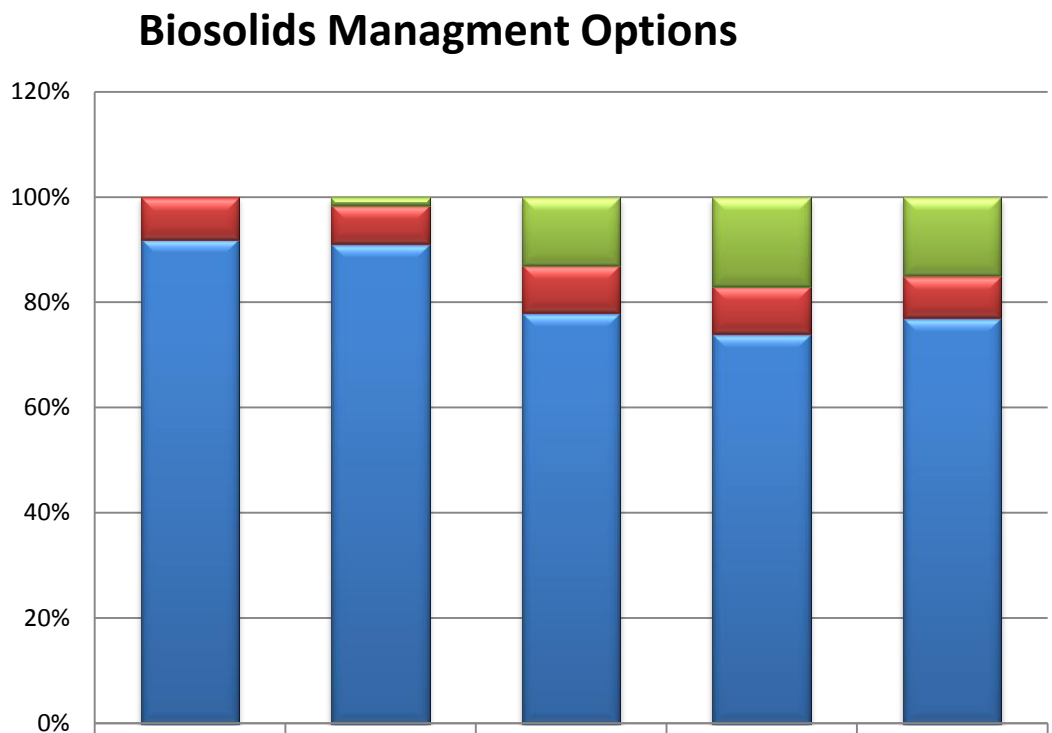
Proposed Project Benefits	Project Outcome
Reduction in air emissions and greenhouse gases (due to reduction in trucking)	Eliminated 13.4 tons of NOx and 124 tons of CO
Reduction in truck traffic outside the Los Angeles Basin	Eliminated approximately 1.1 million miles of heavy truck traffic and its associated emissions, pollutants, odors, and dust outside of Los Angeles Basin
Protection of groundwater, improvement of air quality and odor free operations	Diverted more than 150,000 tons of biosolids from land application resulting in decreased air quality emission, no odors and increased protection of groundwater
Reduction in Brine and Effluent discharged into Los Angeles Harbor (Port).	A decrease in the amount of brine and effluent discharged into LA Harbor, resulting in reduction of environment impact to Harbor.
Reduction in Greenhouse gases	Sequestered more than 16,000 metric tons of CO2
Reduction in Management Costs	Reduced biosolids program management cost by $3 million.
Diversification of Biosolids Program New Innovative Technology	17 percent of biosolids placed in deep subsurface creating less biosolids managed through composting and land application and creation of another management option
Local Management Option	Managing City material at City-owned Facility

Program Costs



2011-Increase in program Costs related to increase in fuel costs

Injection Trends:



	2008	2009	2010	2011	2012
Deep Well Injection	0%	2%	13%	17%	15%
Compost	8%	7%	9%	9%	8%
Land Application	92%	91%	78%	74%	77%

2008
- 150 wet tons per 5 day week

2009
- More then 40 million gallons of bio-slurry material, 1.75% of all biosolids produced at TIWRP injected

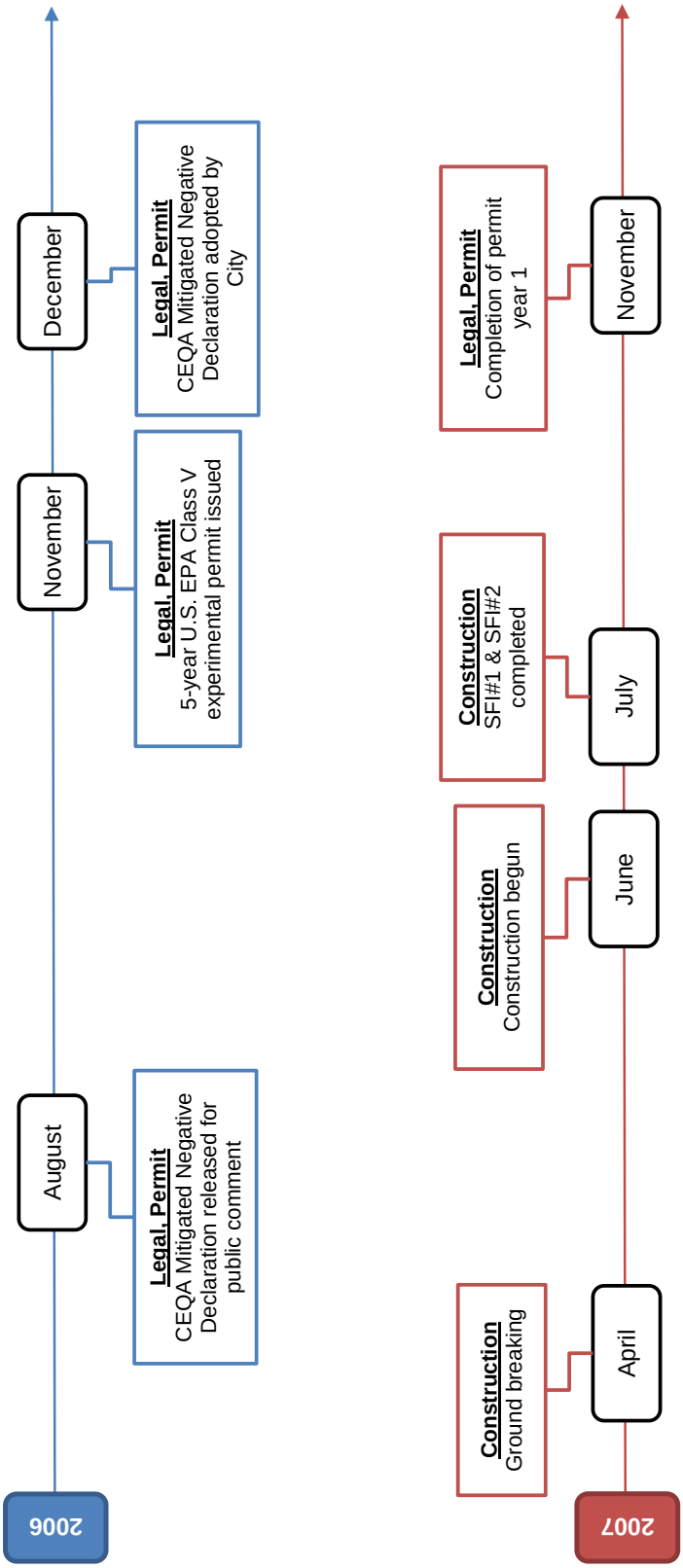
2010
- More than 100 million gallons have been injected, 13% of the 230 thousands tons of biosolids produced

2011
- More than 150 million gallons have been injected, 17% of the 250 thousand tons of biosolids produced

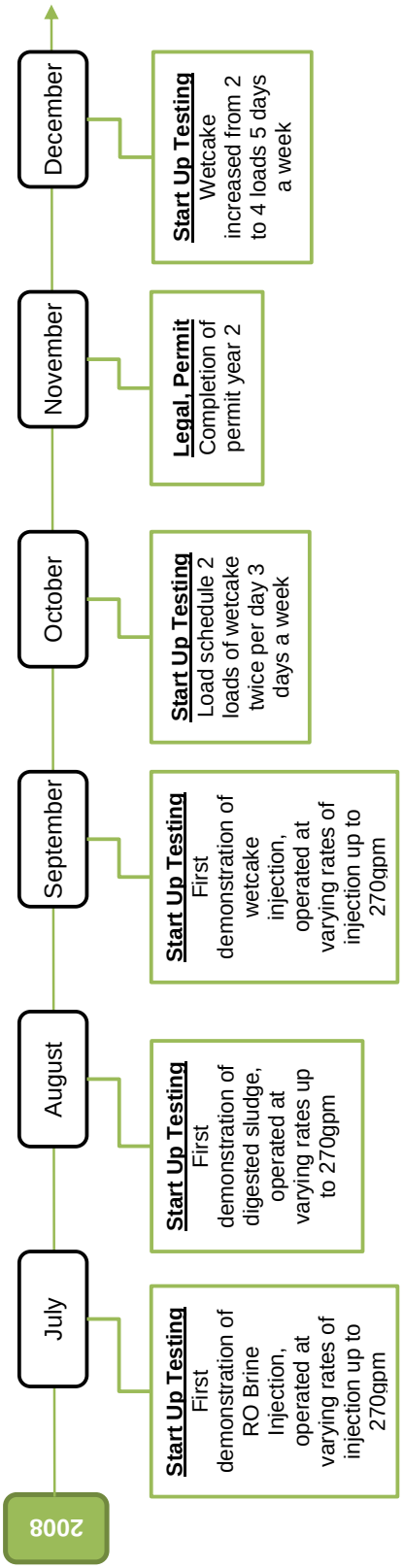
2012
- More than 200 million gallons have been injected, 15% of the 240 thousand tons of biosolids produced

Awards and Recognitions:

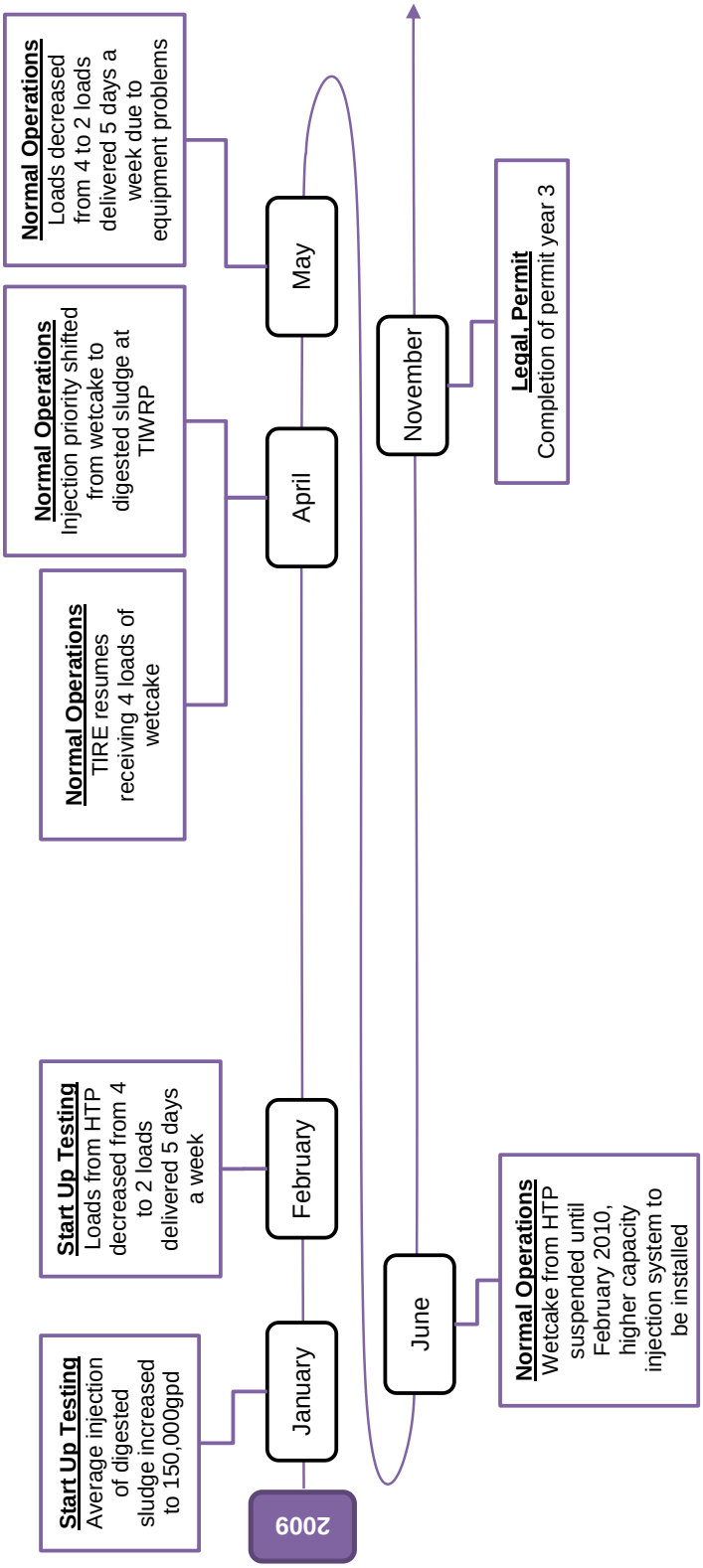
Timeline: August 2006 – November 2007 (Permitting and Construction)



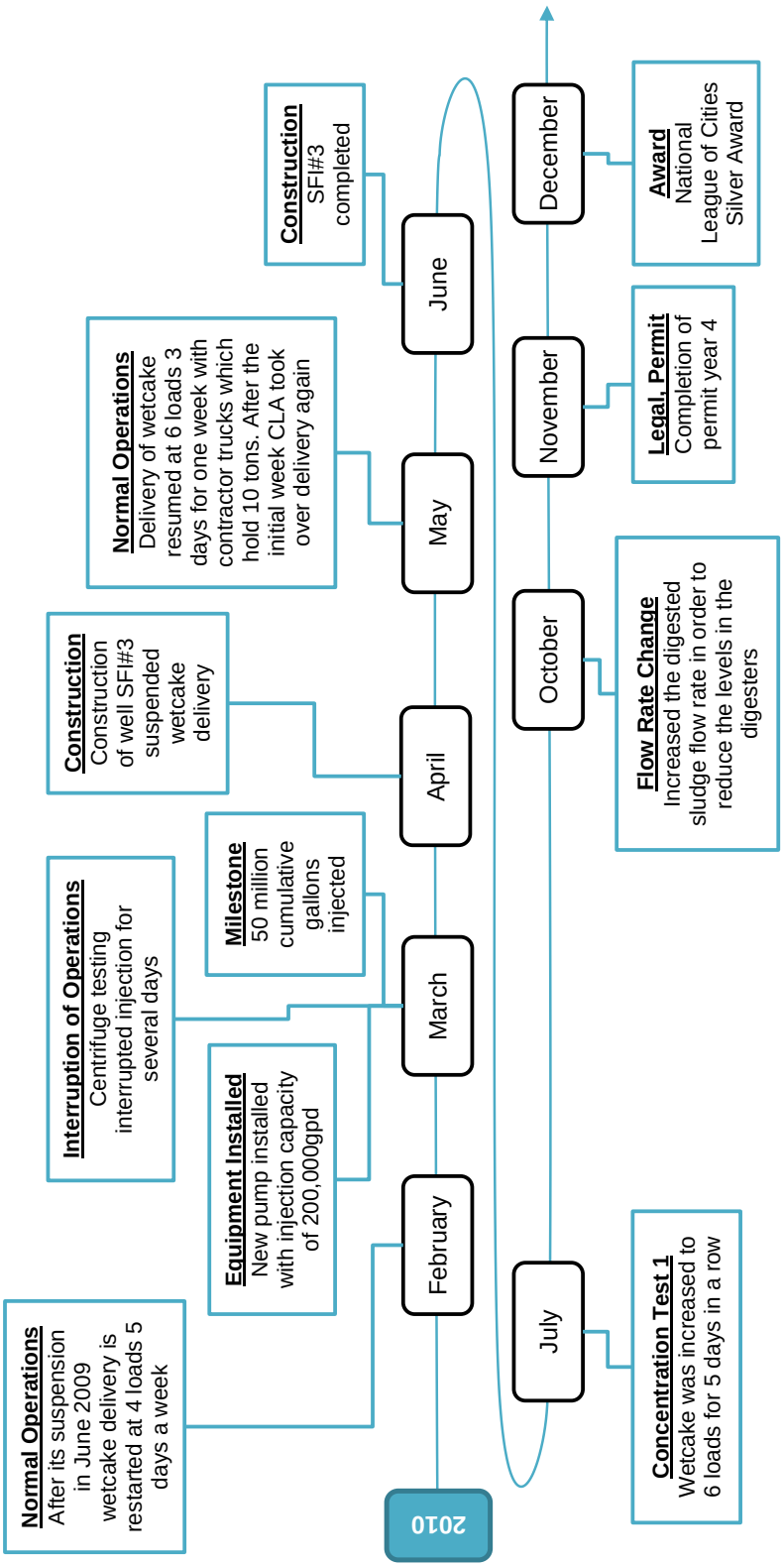
Timeline: 2008 (Start-Up, Operations & Milestones)



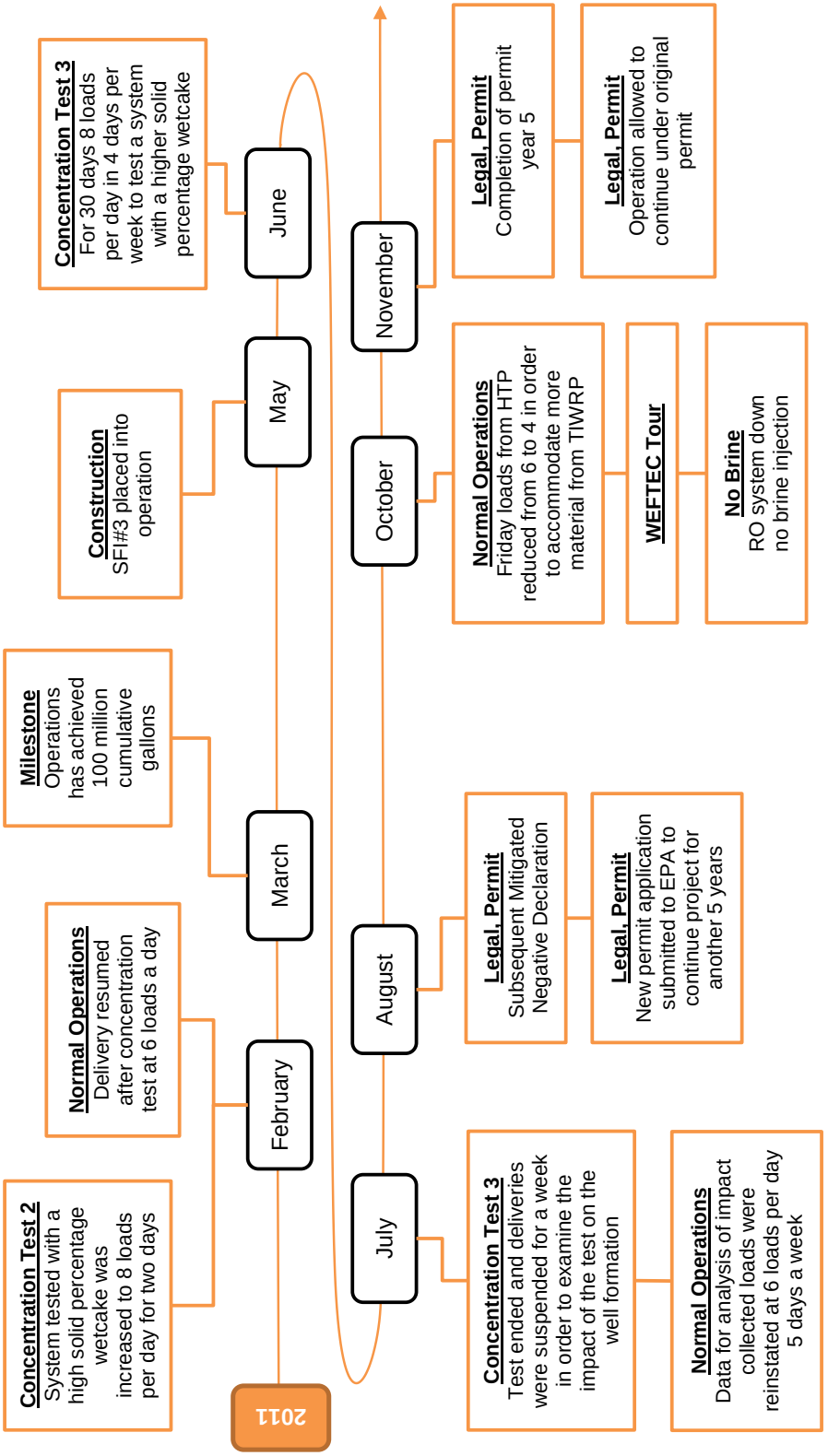
Timeline: 2009 (Operations & Key Milestones)



Timeline: 2010 (Operations & Key Milestones)



Timeline: 2011 (Operations & Key Milestones)



Timeline: 2012 (Operations & Key Milestones)