

Underground Injection Control Program

PERMIT

Class V Experimental
Permit No. R9UIC-CA5-FY11-3R CA

Well Names:

SFI-1, SFI-2 SFI-3 and SFI-4
Los Angeles County, California

Issued to:

City of Los Angeles
Bureau of Sanitation
445 Ferry St.
San Pedro, California 90731

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PART I. AUTHORIZATION TO CONSTRUCT AND INJECT

Pursuant to the Underground Injection Control (UIC) regulations of the U.S. Environmental Protection Agency (EPA) codified at Title 40 of the Code of Federal Regulations (CFR), Parts 124, 144, 145, 146, 147, and 148,

City of Los Angeles
Bureau of Sanitation
445 Ferry St.
San Pedro, California 90731

is hereby authorized to construct and operate a Class V Experimental municipal biosolids injection facility with one or more injection wells and at least two monitoring wells. The wells are to be located within the Terminal Island Plant boundaries.

In addition to the three existing wells, SFI-1, SFI-2 and SFI-3, this permit authorizes drilling and construction of an additional well (SFI-4) to a target depth of 7,500 ft TVD (True Vertical Depth). Existing Wells SFI-1, SFI-2 and SFI-3 may also be deepened to 7,500 ft TVD if the deeper geological interval encountered during the drilling of SFI-4 is determined to be advantageous.

This renewal permit authorizes injection into the Repetto and Puente formations for the purpose of injecting slurry mixtures of treated, non-hazardous, municipal sludge and other wastewater residuals. The permit allows continued injection at pressures sufficient to create hydraulic fractures to demonstrate an experimental technology whereby the municipal waste slurry undergoes high-temperature anaerobic biodegradation. Extensive field monitoring, sampling and analysis from monitoring wells is mandated by the permit to quantify numerous parameters, including slurry placement, biodegradation rates, carbon dioxide and methane separation, carbon sequestration and saturation in formation brine, free gas migration, commercial methane production potential and timeframes. After the requirements of Part II, Section C.6. of this permit have been met, and Well SFI-4 has been drilled and constructed, EPA may approve alternating injection into Wells SFI-1 and SFI-3.

All conditions set forth herein are based on Title 40 Parts 124, 144, 145, 146, 147 and 148 of the Code of Federal Regulations.

This permit consists of twenty-four (24) pages plus Appendices, and includes all items listed in the Table of Contents. Further, it is based upon representations made by City of Los Angeles (the permittee). It is the responsibility of the permittee to read, understand and comply with all terms and conditions of this permit.

This permit and the authorization to inject are issued for a period of up to five (5) years unless terminated under the conditions set forth in Part III, Section B.1. of this permit.

Issued this _____ day of _____.

This permit shall become effective immediately upon the date of issuance.

signed by Jane Diamond 12/23/2013

Jane Diamond, Director
Water Division, EPA Region IX

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PART II. SPECIFIC PERMIT CONDITIONS

A. WELL CONSTRUCTION

1. "Onshore Well Regulations" of the California Code of Regulations

The permittee shall conduct both drilling and plugging operations by following the requirements of this permit and adhering to the standards of the "Onshore Well Regulations" of the California Code of Regulations, found in Title 14. Natural Resources, Division 2. Department of Conservation, Chapter 4, Article 3, Section 1722-1723 as implemented by the Division of Oil, Gas, and Geothermal Resources (DOGGR). It is optional, but not necessary to obtain a separate permit from the DOGGR.

2. Construction Plans and Schematics

The construction plans and schematics submitted with the permit application are hereby incorporated into this permit as Appendix A, and shall be binding on the permittee to the extent that the basic construction scheme is accurate pending the exact depths of the geology encountered during the drilling process. The actual depths of the geological zones are expected to occur within close proximity to the proposed depths, as evidenced from knowledge of the geology of the Wilmington Oil Field. Therefore, the actual setting depths of the casing strings may vary by a minor amount. Any such changes will be approved by EPA before they are enacted and are considered minor in this permit. The exact dimensions of the casing strings and tubing may vary by a minor amount because of the dimensions of various tools and equipment that are commercially available. These changes will be approved by EPA before they are enacted and are considered minor in this permit. Notwithstanding any other provisions of this permit, the permittee shall case and cement the wells to prevent the movement of fluids into or above underground sources of drinking water.

Wells SFI-1, SFI-2, SFI-3, and SFI-4 shall be equipped with retrievable or permanent monitoring systems depending on the role these wells play, i.e. monitoring versus injection. These details are included in Appendix A

The following specifications apply to the wells:

(a) Monitoring/Injection Well SFI-1:

Injection well SFI-I was constructed in July 2007. SFI-1 started receiving bio-slurry material (brine, effluent, digested sludge and biosolids) in July 2008. The material is injected approximately 5200 feet below subsurface using two (2) 500 horsepower pumps. Normal steady-state operation is to inject a volume of 150 wet tons of bio-slurry material for 10 to 13 hours Monday through Friday at an average rate of 8.3 barrels per minute (bpm). Temperature, pressure, and volume of material injected are monitored continuously. Weekly progress summary reports (See Appendix B) showing well performance and operations are provided and quarterly regulatory reports are submitted to the U. S. EPA. (See Appendix C for injection operations data for SFI-1) SFI-1 will remain classified as an injection well in this permit, but will also be utilized to gather monitoring data while injection operations occur in SFI-3. This permit allows for injecting in both Wells

SFI-1 and SFI-3, but solely on an alternating basis, i.e. one well injecting and one well monitoring at any given time. See Appendix A for current SFI-1 well configuration.

PERFORATIONS in SFI-1 were initially at 5,186 ft. – 5,206 ft.; 6 shots/ft.; 0.433 in. diameter holes. A second set of perforations were added at 5,176 ft. – 5,196 ft.; 6 shots/ft.; 0.32 in. diameter holes. This perforation interval reflects the injection zone that is currently authorized in this permit per Part II.A.3. Perforations may be systematically extended uphole within the permitted portions of the Repetto formation which are between the well depths 3,800 - 5,300 ft TVD (True Vertical Depth). These interval changes must be requested in writing in advance, including detailed proposed procedures for construction and for properly isolating the lower perforation interval, and perforating the upper interval. These perforation interval changes must be approved by EPA before they are conducted and are considered minor in this permit. As noted above and further described below, this permit authorizes the drilling of a fourth well (SFI-4) to a depth of approximately 7,500 ft TVD. SFI-1 may be deepened to 7,500 ft TVD if the deeper geological interval encountered during the drilling of SFI-4 is determined to be advantageous. Construction plans and schematic are included in Appendix A. Any such deepening of SFI-1 requires advance notice in writing, including detailed proposed procedures for construction for EPA's review and approval. The permittee must also provide at least 30 days advance notice of operations, including a timeline of operations after receipt of approval of those proposed procedures from EPA.

(b) Monitoring Well SFI-2:

SFI-2 was constructed in July 2007 as a monitoring well and will continue in this capacity. Monitoring of microseismic and temperature in SFI-2 began in November 2008. Microseismic monitoring was discontinued in SFI-2 and began in SFI-3 in May 2011. Temperature and bottom hole pressure monitoring continues in SFI-2. Permittee shall obtain and test representative formation fluid samples from SFI-2 at periodic intervals, quarterly at a minimum, as approved by EPA. SFI-2 will remain a monitoring well under this permit. See Appendix A for current SFI-2 well configuration. Well SFI-2 is currently perforated at 4,730 - 5,002 ft. This perforation interval reflects the injection zone that is currently authorized in this permit per Part II.A.3. SFI-2 may be deepened to 7500 feet TVD if the deeper geological interval encountered during the drilling of SFI-4 is determined to be advantageous. Construction plans and schematic are included in Appendix A. Any such deepening of SFI-1 requires advance notice in writing, including detailed proposed procedures for construction for EPA's review and approval. The permittee must also provide at least 30 days advance notice of operations, including a timeline of operations after receipt of approval of those proposed procedures from EPA.

(c) Monitoring/Injection Well SFI-3:

SFI-3 was constructed in April 2011 and is currently used as a monitoring well since May 2011. Temperature, bottom hole pressure, and microseismic data are being monitored.

This permit allows for converting SFI-3 from a monitoring well to an injection well following drilling, construction and evaluation of SFI-4. This permit allows for injecting in both Wells SFI-1 and SFI-3, but solely on an alternating basis, i.e. one well injecting and one well monitoring at any given time. Injection into SFI-3 will be authorized when specific operational scenarios and triggers are met. The operational scenarios and triggers for injection into SFI-1 and SFI-3 are included in Appendix D. See Appendix A for current SFI-3 well configuration. Well SFI-3 is currently perforated at 5086-5106 ft. This perforation interval reflects the injection zone that is currently authorized in this permit per Part II.A.3.

Perforations may be systematically extended uphole within the permitted portions of the Repetto formation which are between depth interval 3,800 - 5,300 ft TVD. Additionally, SFI-3 may be deepened to 7500 feet TVD if the deeper geological interval encountered during the drilling of SFI-4 is determined to be advantageous. Construction plans and schematic are included in Appendix A. Any such deepening of SFI-3 requires advance notice in writing, including detailed proposed procedures for construction for EPA's review and approval. The permittee must also provide at least 30 days advance notice of operations, including a timeline of operations after receipt of approval of those proposed procedures from EPA.

(d) Monitoring Well SFI-4:

SFI-4 is to be used solely as a monitoring well. It shall be constructed before any well injection operations commence in well SFI-3. The construction of SFI-4 shall conform to all the requirements in Part II, Section C.1. Well SFI-4 will be drilled to a depth of approximately 7500 feet TVD. See Appendix A for proposed SFI-4 well configuration.

The detailed schematic shall be updated as a minor modification to this permit once construction of SFI-4 is completed.

3. Proposed Changes and Workovers Including Replacement of Existing Wells

Proposed changes and workovers, including replacement of all wells, are subject to approval by the EPA Region IX Water Division Director. Drawings and schematics shall be included with the plans detailing the changes and workover activities. If replacements wells are necessary, plugging and abandonment procedures for the well(s) being replaced shall be submitted for EPA approval and plans for replacement well(s) including construction details and schematics shall be provided for EPA approval. The permittee must also provide at least 30 days advance notice of operations, including a timeline of operations after receipt of approval of those proposed procedures from EPA.

The permittee shall give advance notice in writing to the EPA Region IX Water Division Director (Director) of any planned physical alterations or additions to the permitted wells including replacement wells. Any changes in the well construction not

identified within this permit will require prior approval of EPA and a permit modification under the requirements of 40 CFR §144.39. In addition, the permittee shall provide all records of well workovers, logging, or other subsequent test data, including required mechanical integrity testing, to EPA within thirty (30) days of completion of the activity. Appendix E contains the linked websites for the appropriate reporting forms. Demonstration of mechanical integrity shall be performed within thirty (30) days of completion of workovers or alterations and prior to resuming injection activities, in accordance with Part II, Section C.4.

B. CORRECTIVE ACTION

There are no wells located within the Area of Review that require corrective action pursuant to 40 CFR §144.55 and 40 CFR §146.7. In addition, the sequence of formations that are authorized for use as injection zones shall be evaluated for their ability to provide containment of slurry fracture injection, their volumetric and areal extent of zonal reservoir continuity, their cumulative performance and response to slurry fracture injection, and their pressure influence at the location of the three improperly plugged and abandoned wells (Superior Well B-1, Apex Hards-Warnock Well 1, and SP LA Harbor Well 301) (See Part II.C.7.c.).

C. WELL CONSTRUCTION AND OPERATION

EPA has approved the permittee's evidence of Financial Assurance in accordance with Part II, Section F of this permit. Thus the permittee may commence construction or reconstruction/deepening upon completion and EPA approval of the well construction and operation requirements set forth in this section.

The permittee shall demonstrate that SFI-4 (and any deepened or replacement well) has mechanical integrity in accordance with Part II, Section C.3 of this permit. The permittee may not commence operation of SFI-4, any deepened well, or any replacement well until it has received written notice from the EPA that such a demonstration is satisfactory.

1. Logging and Sampling

- (a) The permittee shall conduct Formation Evaluation wireline logging and sampling operations in Well SFI-4, any existing well that is deepened, and any replacement wells. The specific requirements for logging, sampling, and analysis are listed in (i) through (xiii) below. The results of the required logging, sampling, and analysis must be provided to EPA and shall be used to estimate and report values for hydrocarbon saturation, porosity, lithology, formation dip direction, rock mechanical properties for both the injection zones and confining zones identified within the permitted geological sequence. These results shall be provided in a report within 60 days of completion of drilling and construction.
 - (i) Spontaneous Potential (SP) logs shall be used in the open hole
 - (ii) Gamma Ray logs shall be used in the open hole as well as in the cased hole.
 - (iii) Resistivity logs shall be used in the open hole.
 - (iv) Sonic logs shall be used in the open hole.

- (v) Neutron or Density-Neutron logs shall be used in the open or cased hole.
- (vi) Dipmeter logs shall be used in the open hole.
- (vii) Thermal Decay logs shall be used in the open or cased hole, if applicable.
- (viii) Mud log sampling and analysis shall be conducted during drilling operations. Samples shall be retained and stored in a manner that is approved by EPA.
- (ix) Sidewall cores (approximately, but no less than 30 SWC) shall be obtained from Well SFI-4 through the entire interval from 3,800 - 7500 ft. TVD covering the Repetto formation, and the Puente formation and analyzed for porosity, permeability, saturations of water and oil. The formation intervals from which the cores will be taken shall include confining zones (shales) and injection zones (sandstones).
- (x) For each cemented string of casing, cement logging tools shall be of a pad-type, spherically focused cement evaluation tool that is capable of identifying channels and evaluating bondings of cement-to-casing and casing-to-hole.
- (xi) Open hole fluid samples shall be obtained to gather data on fluid geochemistry and biological constituents. Samples shall be obtained after sufficient backflow has occurred to flush out the effects of drilling and completion. Additional samples shall be procured for participating independent research institutions involved in supportive efforts such as determining the native species of microbes present and identification of those species with potential for biodegradation activity, especially that activity supporting, confirming and quantifying methanogenesis. Reports regarding details of the sampling program, and updating the results of efforts and progress of the independent research institutions shall be submitted to EPA in the quarterly reports as they become available.
- (xii) The possibility of expressions of the Palos Verdes or any other fault intersecting the wellbores will be investigated and fully discussed, with the results reported using standard geological techniques including using a combination of data obtained by logging and sampling during drilling operations for wells SFI-4, any deepened or replacement wells, and other data and information including representative wells from the nearby Wilmington Oil Field.

2. Operations

- (a) Fracture simulation modeling results shall be modified when new data is obtained during the drilling, construction and operation of well SFI-4 and at any time the simulation model's parameter values become more accurately known or measured. The permittee shall include these modified modeling results in the quarterly reports. The reports shall justify and identify the parameters used in the modeling, their values, and their accuracy. The report must also interpret any deviations or discrepancies between predicted and measured data.

(b) Reservoir simulation shall be used to estimate and locate gas generation and migration. However in the absence of existing commercially available software with an industry accepted methodology, the permittee shall provide details on the progress of the TOUGH2 method of calculation that is being developed and used. Whenever changes are made to the TOUGH2 application modeling and/or its parameters, they must be justified and approved following review by EPA.

(c) Mechanical Integrity

The injection wells and the monitoring wells have mechanical integrity when there is no significant leak in the casing, tubing or packer, when there is no significant fluid movement into an underground source of drinking water through vertical channels adjacent to the well bore, and when there is no unauthorized fluid movement through vertical channels adjacent to the well bore.

3. Methods for Demonstrating Mechanical Integrity

(a) Annular Pressure test:

An annual (every 12 months) demonstration of the absence of significant leaks in the casing, tubing and/or packer shall be made by performing a pressure test on the annular space between the tubing and long string casing of the injection wells. This test shall be for a minimum of thirty (30) minutes at a pressure equal to the maximum authorized operating injection pressure. A well passes the annular pressure test if there is less than a five (5) percent decrease/increase in pressure over the thirty 30 minute period. A pressure differential of at least 350 pounds per square inch (psi) between the tubing and annular pressures shall be maintained throughout the test.

(b) Thermal/Pressure Monitoring and Analysis:

Injection Wells SFI-1 and SFI-3 are to be fitted with a fiber optic temperature sensor on the long string casing. Real time temperature data will be continuously recorded and displayed in the operator's control room. Reports shall graphically display monitoring results.

(c) A permanently installed surface recording BHP/BHT temperature and pressure gauge will be installed in the monitoring wells SFI-2 and SFI-4.

4. Demonstrations of Annular Pressure for Mechanical Integrity

(a) An annular pressure test shall be demonstrated annually (every 12 months, reasonable exceptions must be justified) or any time that a workover is conducted, the packer is unseated, or the construction of the well is modified.

(b) It is the Permittee's responsibility to arrange and conduct the annular pressure test demonstrations. The permittee shall notify the EPA of its intent to annually demonstrate mechanical integrity at least thirty (30) days prior to each demonstration. Results of the tests shall be submitted to the EPA as soon as possible but no later than thirty (30) days after the demonstration.

(c) In addition to any demonstration made under items (a) and (b), the EPA may require a demonstration of annular pressure test at any time during the life of the wells.

(d) Failure to test and submit these results shall constitute a violation of the terms of the permit and may be cause for revocation.

5. Loss of Mechanical Integrity

If (1) any well fails to demonstrate mechanical integrity during any test or (2) a loss of mechanical integrity becomes evident during operation or (3) a significant change in either the annulus pressure or the injection pressure occurs during normal operating conditions, injection activities shall be terminated immediately and the permittee shall notify the EPA in accordance with Part III, Section E.10 of this permit. Furthermore, operation shall not be resumed until the permittee has taken necessary actions to restore mechanical integrity to the well within 180 days and EPA gives approval to recommence injection.

6. Injection Zones

Injection shall be permitted and systematically authorized for the authorized injection intervals for SFI-1 and SFI-3 which are expected to occur at depths ranging from 3,800 ft. to 7,500 ft. TVD as indicated from offset well records and logs.

The sequence of formations that are considered to be possibly suitable for use as injection zones shall be evaluated for their ability to provide containment of slurry fracture injection, their volumetric and areal extent of zonal reservoir continuity, their cumulative performance and response to slurry fracture injection, and their pressure influence at the location of the three improperly plugged and abandoned wells (Superior Well B-1, Apex Hards-Warnock Well 1, and SP LA Harbor Well 301) (See Part II.C.7.c.).

Initial injection in Well SFI-3 shall occur at the equivalent injection interval that corresponds to the geological formation encountered at the location of Well SFI-1 (5,150 - 5,219 feet TVD. The current approved injection zone occurs in Well SFI-1 from 4,800 to 5,210 feet TVD. However, if this injection interval proves not usable as an injection zone, other injection zones may be systematically considered for injection within the Repetto (Pliocene Age) and Puente (Miocene Age) formations. The top of the portion of the Repetto Formation that is approved for injection can be found at approximately 3,800 feet TVD, and the top of Puente Formation can be found at approximately 6,000 feet TVD. These perforation interval or injection zone changes shall be requested in writing and proposed procedures will include plans for placement of cement, cement squeezing or via another isolation mechanism for the perforated injection interval, testing of the isolated interval (if cleaned out) or the plugged interval (if not cleaned out), and perforating the next injection interval. These injection interval changes must be approved by EPA before they are enacted and are considered minor modifications in this permit. These alterations and other rework operations that may occur later in the course of operation of the wells must be properly and thoroughly reported, including submittal of EPA Form 7520-12. The Permittee must demonstrate that each well has mechanical integrity in accordance with Part II, Section C.3 before any injection is authorized.

SFI-4 will be drilled to approximately 7500 feet TVD. The geology shall be examined for suitability for injection into Wells SFI-1 and SFI-3. Injection into SFI-3 is allowed only after drilling and completing SFI-4. If injection is determined to be suitable,

Wells, SFI-1, SFI-2 and SFI-3 may be deepened to approximately 7500 feet TVD. More detail on these proposed construction plans, operational scenarios, procedures, and accompanying schematics are located in Appendix A and Appendix D.

7. Injection Pressure, Fracture Limitation

- (a) In the event that pressure in any authorized injection zone initiates new fractures or propagates existing fractures in the corresponding confining zone that are permeable and capable of allowing leakage out of that injection zone, the permittee shall notify EPA. Permittee shall obtain authorization from EPA to continue slurry fracture injection in the overlying, sequential injection zone in those cases when the fractures migrate out of the currently authorized zone. Permittee's request for such authorization shall include a detailed analysis and determination of the fracture propagation.
- (b) In no case shall injection operations cause the movement of injection or formation fluids into an underground source of drinking water.
- (c) In no case shall injection operations cause the reservoir pressure of the currently authorized or any previously authorized injection zones to increase at the location of the three improperly plugged and abandoned wells (Superior Well B-1, Apex Hards-Warnock Well 1, and SP LA Harbor Well 301). The predicted reservoir pressures at these locations shall be updated and addressed in the quarterly report using an approved method of analysis of data and information obtained during the various monitoring operations. This analysis shall be fully described and submitted for review by EPA.
- (d) If there is evidence upon drilling to the targeted depth of approximately 7,500 ft. that fault(s) intersect the injection reservoir and/or the wellbores, the reporting requirements for microseismic and pressure falloff monitoring shall include a discussion that addresses injection related activity that occurs in the proximity of this or any other fault plane.
- (e) For reporting purposes the pressure, volume and other pertinent data shall be captured at sufficient frequency as determined by EPA to allow for analyses comparing radial and linear well test analysis procedures. The procedures and analyses shall also be adapted for satisfying the experimental objective that is focused on demonstrating and continually developing the conceptual understanding and therefore the predictive reliability of slurry fracture injection. Analysis of transient data shall include comparing the results of ODA Code Program (established by Lawrence Berkeley National Laboratory) to any other modeling analysis tool chosen to be used by the Permittee. This comparison shall be submitted to EPA for discussion and approval.

8. Injection Rate Limitation

- (a) The injection rate limitation is the operational pump capacity, currently 10 bpm.
- (b) The permittee may request an increase in the rate (pumping capacity) allowed in paragraph (a). Any such requests shall be made in writing in advance to the Director and are subject to approval by EPA.

- (c) Any request for an increase in injection rate shall contain detailed information supporting such a request and provide assurance to the satisfaction of the Director that the increase will not interfere with the operation of the facility or its ability to meet the conditions described in this permit. The request shall also include an initial monitoring program that demonstrates to the satisfaction of the Director that these assurances were reasonably accurate in their prediction.

9. Injection Fluid Limitation

- (a) The permittee shall not inject any hazardous waste as defined by 40 CFR Part 261 at any time.
- (b) Injection fluids shall be limited to only wastewater treatment plant fluids and slurries formed from combining biosolids authorized by this permit and produced at the following facilities: (1) Hyperion Treatment Plant; (2) Terminal Island Water Reclamation Plant; (3) Carson Treatment Plant; and (4) Orange County Treatment Plant. No other sources shall be accepted. The amounts of wastewater treatment fluids and biosolids from each of these facilities shall be identified in the weekly project summary reports (refer to section 10(a) below).

10. Slurry Fracture Injection Process, Related Operations and Analyses

This permit authorizes several operational scenarios related to the slurry fraction injection process and operations of injection wells SFI-1 and SFI-3. See Appendix D for details on operational scenarios and specific triggers for injection operations

(a) Injection Parameters

Injection operations are planned for 8-12 hours per day for wells SFI-1 and SFI-3, with corresponding 2 day shut-in periods for each well per week. Typical injection parameters are summarized in “Table 1 Injection well proposed injection parameters and operating data (per well)” below. Project summary reports shall be prepared and distributed on a weekly basis, in addition to the regulatory reporting in the quarterly EPA report. Project summary weekly reporting will include at a minimum records of daily injection volumes, cumulative volume, rates, bio-slurry solids concentration of injectate, and monitoring and injection well pressures (bottom hole, BHP and wellhead, WHP). These data can be viewed online at <http://www.geoenvironment-technologies.com>.

Table 1 Injection well proposed injection parameters and operating data (per well)

Average daily operation procedures	15 min Pre-slurry injection of wastewater treatment fluids, 8 - 12 hrs biosolids slurry injection, 45 min post slurry injection of wastewater treatment fluids
Average daily rate of injection	8 barrels per minute (bpm)
Average daily volume of injectate	5,000 barrels (bbls)
Maximum daily rate of injection	10 bpm pump capacity
Maximum daily volume of injectate	9,000 bbls pump capacity
Average daily biosolids injection	100 – 200 wet tons
Slurry density	1.0 – 1.5 specific gravity
Viscosity	1 to 100cP
Average surface injection pressure	3,200 psi
Maximum surface injection pressure	3,200 psi corresponds to pump capacity
Average Solids concentrations	5-15% by weight
Nature of annulus fluid	Water (with appropriate corrosion inhibitor)

(b) Pressure Monitoring and Analysis

- (i) Bottom Hole Pressure (BHP) at Injection Well SFI-1 and SFI-3 shall be monitored continuously - during injection (pressure elevation occurs) and shut-in periods (pressure Falloff occurs). After each weekly 2-day shut-in period, injection shall not resume until the BHP has declined to within 10% of the value at the beginning of the previous week. Until the BHP is able to be continually measured, the permittee shall continue to provide upgrades, with justification, to the WHP-to-BHP Calculation and these shall be used in comparison to the monthly measured BHP for the Step Rate Tests in order to verify accuracy.
- (ii) The permittee shall utilize both a software with an industry accepted methodology and ODA Code (developed by Lawrence Berkeley National Lab) to analyze the BHP Falloff to determine and predict reservoir and fluid flow system behavior in the general area of the injection zone as well as the near-wellbore regions of Injection Wells SFI-1 and SFI-3. The results from these two methods of analysis shall be compared and discussed (corresponding with the monthly SRT) and in the corresponding Weekly Progress Summary reports (See Appendix B) and discussed in the Quarterly reports.
- (iii) BHP at all monitoring wells shall be monitored continuously. Use of these BHP measurements shall include extrapolating and verifying on a quarterly basis that injection operations at SFI-1 and SFI-3 are not causing the currently authorized or any previously authorized injection zone's reservoir pressure to increase at the location of the three improperly plugged and

abandoned wells (Superior Well B-1, Apex Hards-Warnock Well 1, and SP LA Harbor Well 301).

(c) Step-Rate Testing (SRT) and Analysis

- (i) Permittee shall conduct monthly SRTs at each injection well to evaluate formation parting (fracture) pressure and changes in in-situ stresses. The SRTs consist of a series of stepped increases of rate followed by a period of slurry injection, then a shorter series of stepped rate decreases. The SRT may be conducted up to the maximum allowable injection rate, currently the operational injection rate (10 bpm) that is limited by equipment capability. Modifications to the SRT procedures must be requested in writing in advance and justified based on field observations. The following SRT procedures shall be implemented:

RATE (bbl/min)	DURATION (min)	WASTEWATER TREATMENT FLUIDS
1.0	60	Digested sludge/HPE (High Pressure Effluent)
2.0	60	Digested sludge/HPE
3.0	60	Digested sludge/HPE
5.0	60	Digested sludge/HPE
7.0	60	Digested sludge/HPE
9.0	60	Digested sludge/HPE
8.0	60 or more	Digested sludge
8.0	15 min	HPE
4.0	15 min	HPE
2.0	15 min	HPE
Shut-in	weekend period	

- (ii) Injection rate is gradually increased between steps over a 5-minute interval.
- (iii) Rates are not varied during the 60-minute duration of each step.
- (iv) Injected volumes and rates are recorded for each step at 15-minute intervals.
- (v) Scan rate for BHP monitoring is twenty readings per minute through the duration of the SRT and the extended falloff period that follows.
- (vi) The wellhead valve is closed just as the pump is stopping to prevent flow-back.
- (vii) SRTs are to be analyzed using a software with an industry accepted methodology and using ODA Code (developed by Lawrence Berkeley National Lab) to analyze the BHP that was measured. The main purpose of discussion is for EPA to understand and for the permittee to demonstrate their ability to determine the fracturing dynamics and fracture development

over time in order to develop a better understanding of the data patterns and behavior. The results from these two methods of analysis shall be provided in the corresponding weekly progress summary report, compared and discussed monthly and reported in the Quarterly reports.

(d) Microseismic/ Monitoring and Analysis

The permittee shall install and operate a continuous downhole microseismic monitoring system with best available technology to provide a determination of dimensions and orientation of the fractures. See Appendix A for specific details of these monitoring requirements.

Downhole monitoring shall be performed continuously to provide location of seismic events related to fracturing operations within the currently authorized injection zone and within the adjacent geological confining zone.

11. Modeling and Analysis

(a) Fracture Geometry

Slurry Fracture Injection simulation modeling and analysis shall be performed to provide estimates on general fracture geometry, including at a minimum, fracture-pattern azimuth, thickness and length. The permittee shall perform analyses using industry standard best available technology software, such as "TOUGH 2" which is the software that is currently being used and periodically being developed and adapted by Lawrence Berkeley National Lab. A detailed written analysis shall be provided by the permittee to demonstrate the fracturing dynamics and development, and over passage of time, establishing better confidence in their understanding of the data patterns and behavior. The results from these analyses shall be discussed in the Quarterly reports.

(b) Biodegradation Process Evaluation and Optimization

Samples of standing gas and representative samples of formation fluids representing the current state and qualities of the formation's fluid at each well's location shall be procured both for the Permittee and for participating independent research institutions involved in the experimental research objectives of the City's project. Reports shall be submitted quarterly regarding details of the sampling program, to include the sampling and data quality, methods used, and updated results of efforts and progress by the independent research institutions. During the operational phases of the project, samples from Monitoring Wells SFI-2 and SFI-4 and Injection Wells SFI-1 and SFI-3 shall be extracted and tested for geochemical and biological properties in efforts to quantify and identify at a minimum:

- (i) active species of methanogenic micro-organisms
- (ii) biosolids compaction behavior and volumetric strains associated with methanogenesis
- (iii) in-situ biodegradation of "bio-nutrients" within the liquid phase of the injectate
- (iv) in-situ biodegradation of biosolids

- (v) in-situ generation and behavior of carbon dioxide (CO₂),
 - (vi) in-situ generation and behavior of methane (CH₄),
 - (vii) in-situ generation and behavior of nitrogen
 - (viii) dominant biological species,
 - (ix) frontal extent of biological activity of the injectate (both liquid and biosolids), and
 - (x) presence of pathogenic microbial indicators including fecal coliform
- (c) Experimental Objectives - Monitoring, Analysis and Application

The Class V Experimental classification of this permit is based on the high level of investigation and analyses of previously unknown, complex in situ processes that are fully expected to continue well beyond the period of injection and emplacement of biosolids within distinct geological formations.

Progress is likewise expected throughout this project regarding theoretical predictive analysis and application techniques as new data are acquired and various reservoir and geological characteristics and properties are obtained and confirmed. Reports addressing the experimental objectives, including the ongoing development of experimental theories/hypotheses shall be submitted quarterly. Further, these quarterly reports should reflect any previous related dialogue between EPA and the permittee, to assure continuity in the discussion of the experimental objectives. The experimental objectives include:

- (i) Demonstrate with assurance, to EPA's satisfaction, the technical, practical, conceptual, and environmental understanding of slurry fracture injection disposal at a scale sufficient for application at large municipalities in the U.S., such as at the Los Angeles Terminal Island facility (up to 400 tons per day of biosolids);
- (ii) Apply advanced geophysical monitoring tools and numerical simulation to determine and verify the vertical and azimuthal placement of the slurrified biosolids material in the permitted intervals, below USDWs;
- (iii) Timely and representative formation sampling, analysis using EPA-approved laboratory methods, and computer modeling using EPA-approved techniques to quantify CH₄ and CO₂ generation, migration and geologic stratigraphic accumulation of CH₄; and
- (iv) Document the subsurface biodegradation process through microbial studies.

D. MONITORING, RECORDKEEPING, AND REPORTING OF RESULTS

1. Monitoring

Calibration and Maintenance of Equipment: All monitoring and recording equipment shall be calibrated and maintained on a regular basis to ensure proper working order of all equipment.

2. Recordkeeping

(a) The permittee shall retain records concerning:

- (i) the nature, volume and composition of injected fluids until three (3) years after all the wells have been plugged and abandoned. See Appendix C for first 4 years of operations.
- (ii) all monitoring information, including all calibration and maintenance records and all recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit for a period of at least five (5) years after all the wells have been plugged and abandoned.

(b) The permittee shall continue to retain the records described in paragraphs (a)(i) and (a)(ii) after the specified retention periods, unless it delivers the records to the Director or obtains written approval from the Director to discard the records.

(c) The permittee shall maintain copies (or originals) of all observation records throughout the operating life of the well and make such records available for inspection at the facility. The permittee shall continue to retain such records unless it obtains written approval from the Director to discard the records.

3. Reporting of Results

Quarterly report forms shall be submitted for the reporting periods by the respective due dates as listed below:

<u>Reporting Period</u>	<u>Report Due</u>
Jan, Feb, Mar	Apr 28
Apr, May, June	Jul 28
July, Aug, Sept	Oct 28
Oct, Nov, Dec	Jan 28

Copies of the monitoring results and all other reports required by this permit shall be submitted to the following address:

U.S. Environmental Protection Agency, Region IX
Water Division Ground Water Office (WTR-9)
75 Hawthorne St.
San Francisco, CA 94105-3901

- (a) The permittee shall submit Quarterly reports including results and discussion of the Slurry Fracture Injection Process, Related Operations and Analyses of Part II, Section C.
- (b) The permittee shall provide a narrative description of all significant changes or events, compliance, and noncompliance that occurred during the Quarterly reporting period. The narrative must summarize any noncompliance and significant issues for the quarter submissions reported under Part III, Section E.10 of this permit.
- (c) The permittee shall include the modified fracture simulation and gas migration modeling results in the quarterly reports. The modeling results shall include the ongoing discussion being developed of the justification and identification of the parameters and theoretical bases used in the modeling, their values and their accuracy sufficient for a level of understanding that is satisfactory to EPA and for EPA's approval. The report must also interpret any deviation or discrepancy between predicted and measured data.

E. PLUGGING AND ABANDONMENT

1. "Onshore Well Regulations" of the California Code of Regulations

The permittee shall conduct both drilling and plugging operations by following the requirements of this permit and the "Onshore Well Regulations" of the California Code of Regulations, found in Title 14. Natural Resources, Division 2. Department of Conservation, Chapter 4, Article 3, Section 1722-1723 as implemented by the Division of Oil, Gas, and Geothermal Resources (DOGGR). It is not necessary for the permittee to obtain a permit from the DOGGR.

2. Notice of Plugging and Abandonment

The permittee shall notify the Director no less than sixty (60) days before conversion, workover, or abandonment of a well to allow an opportunity for EPA personnel to witness the plugging and abandonment.

3. Plugging and Abandonment (P&A) Plans

The permittee shall plug and abandon the wells as provided in the P&A Plans in Appendix F, after providing at least 60 days advance notice, including submitting any proposed modification to the detailed plans for the operation, and after receiving written approval from EPA to perform the P&A operation. EPA reserves the right to change the manner in which a well will be plugged if the well is modified during its permitted life, if the well is not consistent with EPA requirements for construction or mechanical integrity, or if plugging standards are revised. The Director may require the permittee to update the estimated plugging cost periodically. Such estimates shall be based upon costs which an independent third party would incur to plug the wells according to the P&A Plans and Schematics in Appendix F.

4. Plugging and Abandonment Report

Within thirty (30) days after plugging a well, the permittee shall submit a detailed report including Form 7520-14 to the Director. The report shall be certified as accurate by the person who performed the plugging operation and the report shall consist of

either: (1) a statement that the well was plugged in accordance with the Plugging and Abandonment Plans, or (2) where actual plugging differed from the Plugging and Abandonment Plans, a statement specifying the different procedures followed.

5. Cessation of Injection Activities

After a cessation of injection operations for two (2) years, the Permittee shall plug and abandon all four wells in accordance with the Plugging and Abandonment Plans, unless it:

- (a) Provides notice to the Director;
- (b) Has demonstrated that the wells will be used in the future; and
- (c) Has described actions or procedures, satisfactory to the Director that will be taken to ensure that the wells will not endanger underground sources of drinking water during the period of temporary abandonment.

F. FINANCIAL RESPONSIBILITY

The permittee has satisfactorily demonstrated financial responsibility and resources sufficient to close, plug, and abandon the underground injection operation as provided in the Plugging and Abandonment Plans. Should there be any change in the permittee's ability to demonstrate financial responsibility, EPA may require alternate methods of financial assurance.

G. DURATION OF PERMIT

This permit and the authorization to inject are issued for a period of five (5) years unless terminated under the conditions set forth in Part III, Section B.1 of this permit.

Monitoring and measurements are expected to continue beyond the period of injection. Any records of sampling and analysis conducted after termination of authorization to inject shall be submitted in the quarterly reporting period schedule.

PART III. GENERAL PERMIT CONDITIONS

A. EFFECT OF PERMIT

The permittee is allowed to engage in underground injection well construction and operation in accordance with the conditions of this permit. The permittee shall not construct, operate, maintain, convert, plug, abandon, or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant (as defined by 40 CFR §144.3) into underground sources of drinking water, if the presence of that contaminant may cause a violation of any primary drinking water regulation under 40 CFR Part 141 or may otherwise adversely affect the health of persons. Furthermore, any underground injection or any other activity not specifically authorized in this permit is prohibited. The permittee must comply with all applicable provisions of the SDWA and 40 CFR Parts 144, 145, 146, and 124. Such compliance does not constitute a defense to any action brought under Section 1431 of the SDWA, 42 U.S.C. § 300i, or any other common law, statute, or regulation other than Part C of the SDWA. Issuance of this permit does not convey property rights of any sort or any exclusive privilege; nor does it authorize any injury to persons or property, any invasion of other private rights, or any infringement of State or local law or regulations. Nothing in this permit shall be construed to relieve the permittee of any duties under all applicable laws or regulations.

B. PERMIT ACTIONS

1. Modification, Revocation and Reissuance, and Termination of the Permit

The Director may, for cause, modify, revoke and reissue, or terminate this permit in accordance with 40 CFR §§124.5, 144.12, 144.39, and 144.40. Also, the permit is subject to minor modifications in accordance with 40 CFR §144.41. The filing of a request for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance by the permittee, does not stay any permit condition. The Director may also modify, revoke and reissue, or terminate this permit in accordance with any amendments to the SDWA if the amendments have applicability to this permit.

2. Transfer of Permit

This permit is not transferable.

C. SEVERABILITY

The provisions of this permit are severable, and if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

D. CONFIDENTIALITY

In accordance with 40 CFR §§2 and 144.5, any information submitted to EPA pursuant to this permit may be claimed as confidential by the submitter. Any such claim must be asserted at the time of submission by stamping the words "confidential business information" on each page containing such information. If no claim is made at the time of submission, EPA may make the information available to the public without further notice.

E. GENERAL DUTIES AND REQUIREMENTS

1. Duty to Comply

The permittee shall comply with all applicable UIC Program regulations and all conditions of this permit, except to the extent and for the duration such noncompliance is authorized by an emergency permit issued in accordance with 40 CFR §144.34. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act (SDWA) and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or denial of a permit renewal application. Such noncompliance may also be grounds for enforcement action under the Resource Conservation and Recovery Act (RCRA).

2. Penalties for Violations of Permit Conditions

Any person who violates a permit requirement is subject to civil penalties, fines, and other enforcement action under the SDWA and may be subject to enforcement actions pursuant to RCRA. Any person who willfully violates a permit condition may be subject to criminal prosecution.

3. Need to Halt or Reduce Activity Not a Defense

It shall not be a defense, for the permittee in an enforcement action, that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

4. Duty to Mitigate

The permittee shall take all reasonable steps to minimize and correct any adverse impact on the environment resulting from noncompliance with this permit.

5. Proper Operation and Maintenance

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up or auxiliary facilities or similar systems only when necessary to achieve compliance with the conditions of this permit.

6. Property Rights

This permit does not convey any property rights of any sort, or any exclusive privilege.

7. Duty to Provide Information

The permittee shall furnish to the Director, within a time specified, any information which the Director may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit. The permittee shall also furnish to the Director, upon request, copies of records required to be kept by this permit.

8. Inspection and Entry

The permittee shall allow the Director, or an authorized representative, upon the presentation of credentials and other documents as may be required by law, to:

- (a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records are kept under the conditions of this permit;
- (b) Have access to and copy, at reasonable times, any records that are kept under the conditions of this permit;
- (c) Inspect and photograph at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
- (d) Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the SDWA, any substances or parameters at any location.

9. Signatory Requirements

All applications, reports, or other information submitted to the Director shall be signed and certified by a responsible corporate officer or duly authorized representative according to 40 CFR §144.32.

10. Reporting of Noncompliance

(a) Anticipated Noncompliance

The permittee shall give advance notice to the Director of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

(b) Compliance Schedules

Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted to the Director no later than thirty (30) days following each schedule date.

(c) Twenty-four Hour Reporting

- (i) The permittee shall report to the Director any noncompliance which may endanger health or the environment. Information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances. The following information must be reported orally within twenty-four (24) hours:

- (1) Any monitoring or other information which indicates that any contaminant may cause an endangerment to an underground source of drinking water;
- (2) Any noncompliance with a permit condition, or malfunction of the injection system, which may cause fluid migration into or between underground sources of drinking water;

- (3) Any monitoring or other information which indicates that injection operations may cause the reservoir pressure to increase at the location of the three improperly plugged and abandoned wells (Superior Well B-1, Apex Hards-Warnock Well 1, and SP LA Harbor Well 301);
 - (4) Any monitoring or other information which indicates that fractures in the immediately overlying confining zone that are permeable and capable of allowing leakage have propagated above the currently authorized injection zone. Permittee shall obtain authorization to conduct slurry fracture injection in the overlying, sequential injection zone before proceeding;
 - (5) Any monitoring or other information which indicates that fractures have propagated downward to basement rock (the Jurassic formation).
- (ii) A written submission of all noncompliance as described in paragraph (c) (1) shall also be provided to the Director within five (5) days of the time the permittee becomes aware of the circumstances. The written submission shall contain: a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times; if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent recurrence of the noncompliance.

(d) Other Noncompliance

At the time monitoring reports are submitted, the permittee shall report in writing all other instances of noncompliance not otherwise reported. The permittee shall submit the information listed in Part III, Section E.10. (c) of this permit.

(e) Other Information

If the permittee becomes aware that it failed to submit all relevant facts in the permit application, or submitted incorrect information in the permit application or in any report to the Director, the permittee shall submit such facts or information within two (2) weeks of the time such facts or information becomes known.