Used Oil Lifecycle Assessment
Report to the Legislature

California Department of Resources Recycling and Recovery

February 2016

STATE OF CALIFORNIA

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Executive Summary

The 1991 California Oil Recycling Enhancement (CORE) Act established a comprehensive used oil recycling program to reduce the impacts of improper disposal while also encouraging the recycling of used oil, which must be managed as a hazardous waste in California.[1] Since the enactment of the CORE Act, CalRecycle has implemented a successful used oil recycling program that has resulted in an infrastructure for collecting, handling, and processing used oil.

The CORE Act established a manufacturer fee and recycling incentive system to fund various activities and encourage generators to recycle their used oil.[2] Accordingly, CalRecycle works in partnership with California cities and counties to ensure convenient access to used oil collection opportunities by establishing a network of certified collection centers (CCCs). CalRecycle administers the certified collection center program and is responsible for certifying centers. The program also awards per capita and competitive grants to local jurisdictions to establish and operate used oil collection programs. Grant funds are used for collection infrastructure such as the establishment of new certified collection centers, used oil recycling costs, used oil filter collection programs, and innovative public education and outreach programs. More than $267 million has been awarded to local jurisdictions since 1994.

The used oil program has been successful in increasing the volume of used oil collected and recycled in the state. In the mid-1990s, between 55 million and 60 million gallons of used oil (both lubricating and industrial oil) were collected annually, with recycling rates below 45 percent. Collection grew to 116 million gallons by 2003, while the collection rate based on collectable oil leveled off at about 72 to 73 percent. Since the program's inception, approximately 1.75 billion gallons of used oil have been collected and managed. Despite the success of the program, a large amount of used oil, perhaps on the order of 36 million gallons annually, still is improperly disposed. About 16 million gallons of this amount is industrial oil.[2] While an estimated 70 to 80 percent of available lubricating oil is collected, only about 55 percent of industrial oil is collected. In addition, there has been extensive debate over the past several years about the relative environmental merits of different end uses for collected used oil. Various studies have been conducted in California and around the world, but none has been comprehensive in examining both the environmental and economic impacts of the various disposition routes.

Accordingly, Senate Bill 546 (Lowenthal, Chapter 353, Statutes of 2009) was enacted, updating the oil recycling act and making significant changes to the program's fee and incentive payment structures. Key provisions of the bill included:

- Increasing the manufacturer fee on used lubricating oil sold in California;
- Increasing the recycling incentive payment for used oil collected from the public while maintaining the incentive for oil generated as part of doing business;

[1] The CORE Act was enacted by Assembly Bill 2076 (Sher, Chapter 817, Statutes 1991).

[2] Used lubricating oils and industrials oils are typically mixed during the collection process and managed together rather than separately. The Department of Toxic Substances Control (DTSC) does not distinguish between these two types of oil, i.e., both are considered "used oil" and therefore hazardous waste. The CORE Act's manufacturer fee currently is assessed only on lubricating oil and excludes industrial oil. Lubricating oil includes oils used to lubricate internal combustion engines while industrial oils include hydraulic, metal working, turbine, compressor, and refrigeration oils.

- Streamlining the used oil grant programs and updating the used oil certified collection center program;
- Promoting the production and use of re-refined oil;
- Instituting new testing requirements for used oil leaving the state;
- Establishing registration and reporting requirements for out-of-state facilities that receive California used oil in order to participate in the incentive program; and
- Directing CalRecycle to:
    - Conduct a comprehensive lifecycle analysis of the used oil and industrial management system;
    - Solicit input from all used oil stakeholders on the lifecycle analysis;
    - Evaluate the impacts of the testing requirements and tiered incentive payments on used oil collection rates; and
    - Submit a report to the Legislature on the lifecycle analysis and evaluation of used oil management policies, including recommendations for statutory changes to promote increased collection and responsible management of used oil.

The ensuing analysis is groundbreaking in scope and complexity, and in the extent of stakeholder involvement. CalRecycle found that improperly disposed used oil results in negative environmental impacts in more impact categories (such as greenhouse gases, ecotoxicity, acidification, etc.) than from any of the legal disposition routes (re-refined lube oil production, distillate fuel production and combustion, or combustion of recycled fuel oil). There is no single "best" disposition route among the three, and collecting more of the used oil that is currently being generated would result in both environmental and economic benefits for California regardless of how the oil is managed once it is collected. However, the results suggest some environmental benefits could be realized if less used oil was processed into and used as recycled fuel oil and instead was processed into and used as a distilled fuel or as re-refined lubricating oils. In addition, the largest benefits are seen when the market value of used oil is increased, resulting in increased collection of used oil and reduced environmental impacts and increased economic benefits. The biggest benefits are found not in shifting from one legal disposition route to another but rather from an illegal uncollected disposition to any of the legal processing options. The differences between legal options are relatively small in comparison.

Stakeholder Process

SB 546 charged CalRecycle with engaging used oil stakeholders (see a full list of participants in Appendix B List of Stakeholders), including local government agencies and other state departments (including the Department of Toxic Substances Control) in the design and scope of the comprehensive lifecycle analysis (LCA), in conducting the LCA, and in reviewing various documents and draft reports. This public process, particularly the consistent participation by key stakeholders from the project's inception to its conclusion, proved beneficial to conducting a broad and complex analysis of the used oil management system from generation through collection, transportation, and reuse alternatives. The inclusion of a broad stakeholder process, an economic analysis, and peer reviewers, along with the level of transparency associated with this project, combine to create an LCA that is qualitatively different than any other LCA completed to date and, despite various uncertainties, can be used for policy-making purposes.

Eleven formal stakeholder meetings were conducted from January 2011 to July 2013, augmented by various topic-oriented webinar meetings held throughout the process and a final stakeholder meeting held in September 2013 to present and solicit comments on CalRecycle's draft preliminary findings. Notes and presentations from these meetings, along with formal stakeholder comments and CalRecycle responses,

can be found on CalRecycle's website.[3] CalRecycle requested formal input from stakeholders at least eight times during the project on topics such as key qualifications for contractors, contractor scopes of work, goal and scope of the LCA, and draft contractor reports. In total, more than 500 comments were submitted from stakeholders and considered by CalRecycle. Formal responses were issued on five separate occasions along with numerous responses to individual entities. While a considerable amount of information was shared by members of the stakeholder group, much of it was shared under the protection of nondisclosure agreements, which diminished the transparency possible with this report. In addition, some stakeholders were unwilling to share certain data at all, resulting in a number of data gaps that required CalRecycle and its contractors to rely on assumptions. Greater confidence would have been gained had stakeholders provided more information and if the information provided could have been shared more openly. These issues regarding data sharing and assumptions are discussed in detail in Appendix A. Despite these issues, CalRecycle believes valid policy recommendations still can be made based on the results of this study.

Key Findings

Based on the extensive lifecycle environmental analysis and economic analysis required by SB 546 and summarized in this report, CalRecycle's major findings are summarized below by each of the major legislative provisions and discussed in more detail in the Results and Key Findings section. While every effort was made to close data gaps, a number of assumptions needed to be made, and there was not full stakeholder consensus with some of the assumptions. Some of the major areas of disagreement concerned data regarding combustion of recycled fuel oil, assumptions concerning displaced products, toxicity impact assessments, and data concerning uncollected oil. Some of these areas of concern could have been solved with a greater willingness to share data, while others are the result of imperfect available research (particularly with regard to metal toxicity and the creation of certain volatile organic compounds during combustion). There were also differences of opinions on the basic modeling conducted by the contractors and the sources of data, some of which were necessarily confidential (as mentioned above). These issues are discussed in the Results and Key Findings section and in the Limitations of the Study section. Each of the contractor reports also details the assumptions made in their analyses.

Legislatively Mandated Findings Related to Public Resources Code (PRC) Section 48651.5(b)(1)(C):
PRC section 48651.5(b)(1)(C) requires CalRecycle to evaluate the impacts on used oil collection rates of the new testing requirements, the tiered fee on lubricating oil, and the tiered incentive payments established in SB 546. These provisions have only been in place for a short time, so analysis is limited. However, to date:

- The increased incentive payment for Do-It-Yourself (DIY) oil changers has not resulted in any appreciable increase in used oil collection volumes;
- The reduced fee for re-refined oil, intended to increase used oil re-refining, has not resulted in increased used oil re-refining;
- Although data is limited, the out-of-state transportation testing requirements have not been shown to have resulted in fewer gallons of used oil leaving California, nor have they resulted in cleaner used oil leaving California; and
- The re-refining incentive payment of $0.02 per gallon began on Jan. 1, 2013. Due to the amount of supporting documentation required for the claim process, the first claim has yet to be fully submitted and reviewed. Because of this, there is insufficient data to draw any conclusion.

[3] http://www.calrecycle.ca.gov/usedoil/LCAProject/default.htm

Legislatively Mandated Findings Related to PRC Section 48651.5(b)(1)(D):
PRC section 48651.5(b)(1)(D) requires CalRecycle to "provide any recommendations for statutory changes that may be necessary to promote increased collection and responsible management of used oil."

As stated previously, a major finding of this study is that improperly disposed used oil results in negative environmental impacts across all impact categories studied in relation to the baseline, and that these impacts are worse than the impacts from any of the formal disposition routes (re-refined lube oil production, distillate fuel production, or combustion of recycled fuel oil). This study also revealed the collection rate for California used oil is higher than previously estimated (between 75 percent and 80 percent of available lubricating oil). Collecting more of the used oil that is currently being generated would result in both environmental and economic benefits for California regardless of how the oil is managed once it is collected. Based on the hypothetical policy scenarios, the largest overall benefits are seen when the market value of used oil is increased, resulting in increased collection of used oil, reduced environmental impacts, and economic benefits.

Another key finding, again, is there is no single "best" option among the three formal disposition routes: re-refining, distillation into marine distillate oil (MDO), and use as a heavy fuel (recycled fuel oil, or RFO). However, there are some minor differences in environmental impacts among these three disposition routes. In particular, the results suggest that some environmental benefits could be achieved if more used oil was processed into a distilled fuel or as re-refined lubricating oil rather than used as RFO. This finding is very controversial and reflects analyses that are based on certain assumptions and that have inherent uncertainty.

Part of the difficulty arises due to the multiple environmental impact categories that were investigated. Because the environmental impact categories span a wide range (greenhouse gases, human toxicity, environmental toxicity, smog formation, etc.), it is difficult to determine which group of impacts is "better" or "worse" than the others, as this involves value judgments that are not in the purview of a formal LCA. It is also difficult to determine whether the differences between two different impacts are significant, due to unquantifiable uncertainties. Furthermore, the models responsible for determining the impacts of RFO combustion rely on a number of assumptions that are uncertain to varying degrees due to the data being out of date or unavailable. Also, these comparative results are not one-directional; for example, the use of used oil as RFO often displaces dirtier fuels, resulting in net environmental benefits in the impact areas of global warming and acidification.

CalRecycle Recommendations
Based on the entirety of the environmental lifecycle assessment, economic analyses, and extensive stakeholder interaction, CalRecycle presents several recommendations that support the legislative goals of promoting increased collection and responsible management of used oil. Thirteen potential policy options are presented and discussed in the Policy and Research Options section of this report. From these 13 options, CalRecycle recommends a suite of seven options, briefly described below, that would work together to achieve waste reduction by decreasing the generation of used oil, increasing collection of used oil that is generated, decreasing the impacts associated with processing used oil, and creating equity where currently inequity exists. CalRecycle does not recommend changes to the testing and reporting requirements established by SB 546.

Most of these seven options will require legislation to adjust the way oil funds are allocated, and all have associated implementation issues that would need to be addressed. Only Options 3 and 4 could be

accomplished administratively. The rationale for these recommendations is discussed in the CalRecycle Policy Recommendations section of this report. Any of the options that change the current used oil fee structure would be subject to Proposition 26 (2010) considerations. While other combinations of potential policy options could be implemented, CalRecycle views these options as the most effective way to increase the collection and proper management of used oil in California.

CalRecycle's recommended policy options are:

- Option 1 – Direct payments to certified used oil collection centers (CCCs). Remove the current per gallon incentives provided to collection centers and Do-It-Yourself oil generators, and replace it with a flat annual payment to CCCs based on their activity. Higher payments would be offered to CCCs in remote areas in order to offset some of the additional collection costs incurred in these areas of California.
- Option 3 – Reestablish and expand the Check Your Number campaign. This public outreach campaign has the potential to decrease the amount of used oil generated by educating consumers regarding the recommended oil change interval for their vehicles (which is often much longer than 3,000 miles).
- Option 4 – Investigate and promote high-efficiency oil filters. Conduct research and implement a demonstration project on the installation of high-efficiency filters and on-board sensors that could extend the useful life of lubricating oils beyond the manufacturer's recommended drain interval.
- Option 6 – Service station reminder stickers. This option includes establishing new requirements for service stations. Service stations that change customer oil would be required to indicate the next recommended oil change service based on the manufacturer's recommended drain interval for their particular vehicle (windshield reminder stickers) rather than the typical 3,000 miles.
- Option 7 – Direct payments to used oil haulers. In order to increase the market value of used oil, provide an incentive payment directly to used oil haulers.
- Option 11 – Create an incentive for distilled fuel production. This option would remove the current disparity between the production of re-refined base lube and distilled fuels made from used oil by establishing an equivalent incentive for the production of distilled fuels.
- Option 13 – Include industrial oils in the fee and incentive system. Subjecting industrial oils to the manufacturer fee and including an incentive for their collection creates equity, provides valuable data, and generates needed revenues to support other recommendations made here.

CalRecycle also provides recommendations regarding further research. This project identified several areas where additional information and research is needed in order to more fully understand the environmental and economic impacts of the used oil management system in California. Some additional research is already planned (see Potential Research Options section). CalRecycle also recommends projects be undertaken to develop models for combustion of used oil and primary refinery impacts, and to conduct research to accurately determine the toxicity impacts associated with various environmental emissions.

Introduction

Senate Bill 546 (Lowenthal, Chapter 353, Statutes of 2009) made significant changes to the California Oil Recycling Enhancement (CORE) Act. This report to the Legislature is required by Public Resources Code section 48651.5(b)(1)(A) through (D), which tasks CalRecycle with the following:

> *(A) Contract with a third-party consultant with recognized expertise in life-cycle assessments to coordinate a comprehensive life-cycle analysis of the used lubricating and industrial oil management process, from generation through collection, transportation, and reuse alternatives.*
>
> *(B) Solicit input from representatives of all used oil stakeholders in defining the scope and design of the life-cycle analysis, in conducting the life-cycle analysis, and in issuing a draft report for public review and comment.*
>
> *(C) Evaluate the positive and negative impacts of the testing requirements established in Section 25250.29 of the Health and Safety Code, the tiered fee on lubricating oil established in Section 48650, and the tiered incentive payments established in Section 48652, on used oil collection rates.*
>
> *(D) On or before January 1, 2014, submit a report to the Legislature, in compliance with Section 9795 of the Government Code, describing the findings of the life-cycle analysis and the evaluation of the used oil management policies on used oil collection rates specified in subparagraph (C) and provide any recommendations for statutory changes that may be necessary to promote increased collection and responsible management of used oil.*

This project is groundbreaking in its scope and complexity. Not only does it go beyond traditional product-focused lifecycle analyses to address a broad and complex industrial system, it also links these lifecycle analyses with extensive economic analyses. The extensive stakeholder input in the lifecycle process, which was required by PRC section 48651.5(b)(1)(B) and is described in detail later in this report, was also unique in the world of lifecycle assessments. The process proved highly beneficial in developing the scope and design of the lifecycle analysis, facilitating exchange of ideas and opinions, bringing a wide range of expertise into the project, and assisting in data compilation.

This report describes the project methodology, discusses key findings of the contractors, presents potential policy options for consideration by the Legislature, and offers recommendations for changes to the used oil program to promote increased collection and responsible management of used oil.

Numerous contractor reports were developed as part of this project, all of which are available to the public and referred to in this report. However, this report is not meant to be an-depth presentation of the contractor reports. Instead, it synthesizes and interprets the findings and results of the contract reports, presents information and input gleaned from the stakeholder process, and discusses the limitations of the contracts and overall study in a manner that is intended to inform discussions of potential policy options and recommendations.

Used Oil Program Background

In 1991, the Legislature passed the California Oil Recycling Enhancement (CORE) Act (Public Resources Code sections 48600–48691) to address the threat to California's environment from improper disposal of used oil. The intent of the CORE Act is "to reduce the illegal disposal of used oil and recycle and reclaim used oil to the greatest extent possible in order to recover valuable natural resources and to avoid damage to the environment and threats to public health" (PRC section 48600). The California Integrated Waste Management Board (CIWMB) was charged with implementing the act. Senate Bill 63 (Strickland, Statutes of 2009) eliminated the CIWMB and transferred its regulatory and programmatic responsibilities to the new Department of Resources Recycling and Recovery (CalRecycle). For this report, the term "CalRecycle" will be used to represent activities of both CIWMB and CalRecycle, except when specific actions or decisions were made by the CIWMB. In those instances, the actions or decisions will be identified.

Management as Hazardous Waste

Used oil has been required to be managed as a hazardous waste in California since the 1980s, subjecting the collection and management of used oil to regulations under the authority of the Department of Toxic Substances Control (DTSC). Health and Safety Code (HSC) section 25250.1 defines used oil and the conditions for managing hazardous waste. Transport of used oil must be tracked and reported to DTSC until it is tested by a permitted facility. Oil that is shown to conform to specific requirements (HSC section 25250.1(a)(3)(A)) is no longer considered to be subject to hazardous waste management rules. It is classified as "recycled oil," which can be burned for energy recovery (HSC section 25250). Every shipment of used oil between facilities must be reported to DTSC on a hazardous waste manifest. The management of used oil as a hazardous waste is an issue raised by several contractors, and CalRecycle's decision not to include this within the modeling analyses is not supported by all stakeholders. Additional information regarding the stakeholder process and this decision can be found in the Scope and System Boundaries section.

The California Oil Recycling Enhancement Act

The CORE Act stated that "on or before October 1, 1992, the state shall adopt a used oil recycling program which promotes and develops alternatives to the illegal disposal of used oil" (PRC section 48630). Key provisions of the CORE Act (prior to the passage of SB 546) included:

1. Oil manufacturers were required to pay CalRecycle $0.16 for every gallon of lubricating oil sold, transferred, or imported for use in California, with revenues being deposited in the California Used Oil Recycling Fund.
2. CalRecycle was authorized to expend the funds only for specified activities including:
    a. To pay a recycling incentive, of $0.16 per gallon, to every small quantity industrial generator, curbside collection program, and certified used oil collection center, for used lubricating oil collected from the public, or generated by the certified used oil collection center or the small-quantity industrial generator, and transported by a used oil hauler to a certified used oil recycling, storage, or transfer facility.
    b. To make annual block grant awards to local jurisdictions on a per capita basis for the development and support of local used oil collection programs (total of $10,000,000 annually).
    c. To provide appropriations for statewide outreach and competitive grants to local jurisdictions, nonprofit organizations, and private entities.

d. To establish an annual reserve of not more than $1,000,000, for administration of the program, and to pay for the reporting and inspection of used oil haulers and facilities by DTSC.

3. CalRecycle was directed to establish a statewide network of certified used oil collection centers (CCCs) to accept used oil from the public free of charge (PRC section 48660). CCCs are allowed to submit claims for the recycling incentive, $0.16 per gallon, of used oil collected and recycled. CCCs must comply with various requirements concerning signage, hours of operation, and public education regarding contaminated oil.

To implement the program, CalRecycle works in partnership with California cities and counties to achieve the goals of the CORE Act. Local agencies provide public education targeted to their residents and ensure convenient used oil collection opportunities by coordinating the certified used oil collection centers (CCCs) in their communities. CCCs are the cornerstone of the used oil program. As of September 2013, there are about 3,500 CCCs throughout the state, including more than 1,000 auto parts stores and 630 "quick lube" shops in addition to marinas, service shops, permanent household hazardous waste facilities, and travel centers. In addition, 237 curbside used oil collection programs provide convenient collection throughout the state. A geographical information systems project completed in 2013 demonstrated that more than 93 percent of California residents live within 3 miles of a CCC, and 97 percent live within 5 miles. Due to a focused effort in recent years, about 37 percent of all CCCs collect used oil filters in addition to used oil from the public.

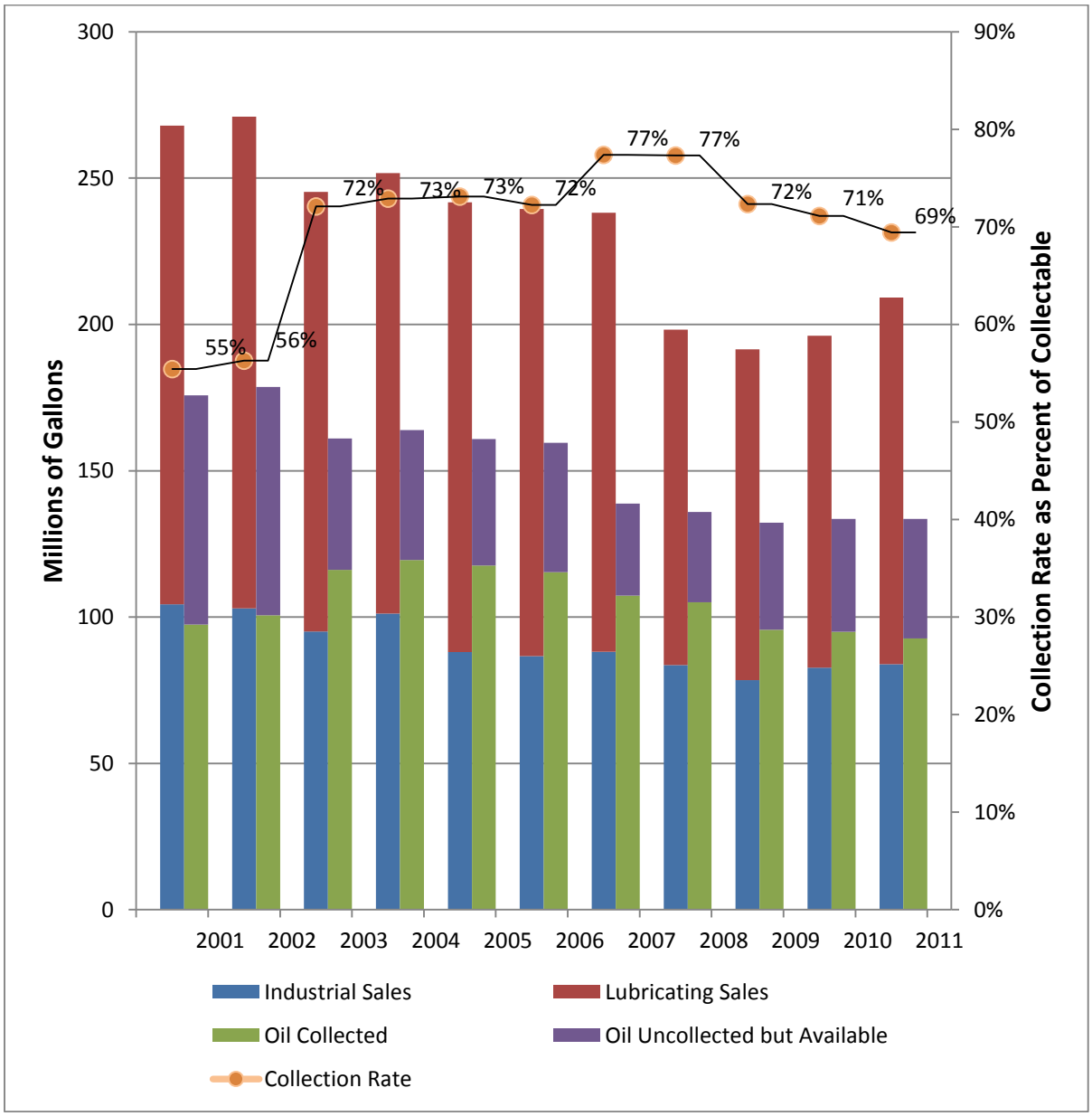
The first used oil block grants were awarded in 1994 to local governments on a per capita basis to set up used oil collection programs. In that same year, more than $8 million in competitive grants was awarded to local agencies for providing opportunities in addition to those supported by block grants. Those early grant funds were often used for collection infrastructure, public education and outreach, establishing new certified collection centers, and used oil recycling costs. As shown in the table below, a total of more than $267 million has been awarded to local jurisdictions in per capita and competitive grants, more than $14.5 million to nonprofit organizations (primarily for public outreach such as "dock walker" programs promoting used oil collection at marinas and collection events), and more than $7.5 million for research and demonstration grants. Other smaller grant programs were offered in the early years of the program as directed in statute.

TABLE 1: CALRECYCLE HISTORIC DATA

Cycle Name	Total Number of Grants	Total Funds Awarded
Used Oil Block Grants and Payment Program (per capita to local jurisdictions)	4,085	$219,108,644
Used Oil Opportunity Grants (competitive to local jurisdictions)	262	$47,994,647
Used Oil Grants for Non-Profit Organizations	121	$14,540,123
Used Oil Research, Testing & Demonstration Grants	39	$7,616,874
Oil Demonstration Program Grants	19	$840,057
Used Oil Local Conservation Corps Grants	11	$600,000
Used Oil Curbside Collection Promotion Grants	25	$1,444,673
Grant Total	**4,562**	**$292,145,018**

The used oil program has been successful in increasing the volume of used oil collected and recycled in the state. In 2001, 97 million gallons of used oil (both lubricating and industrial oil) were collected. Collection grew to 116 million gallons by 2003; then the collection rate based on collectable oil leveled off at about 72 to 73 percent. This trend has remained fairly constant, with some increases in 2007 and 2008 and some small decreases in 2011.

FIGURE 1: HISTORIC OIL SALES AND COLLECTION



A significant amount of effort by CalRecycle and the local jurisdictions is focused on collection of oil generated by Do-It-Yourselfers. Even though the DIY sector as a proportion of the population appears to have decreased significantly during the program's existence, the amount of used oil returned by DIYers for recycling appears to have remained steady. Unlike businesses such as auto parts stores, "quick lubes," and service shops whose used oil management practices are regulated, very little information is known about the behavior and management practices of the DIYer population. DIYers include not only individuals, but also "shade tree mechanics" (individuals, typically unlicensed and unregulated, who change oil for family and friends), small rural growers, and independent truckers in rural areas. DIY outreach and collection opportunities continue to be a focus of the program.

In 2004 and 2005, after the program had been in existence for 10 years, California Polytechnic State University, San Luis Obispo conducted an independent evaluation of the used oil program. The evaluation determined that the program had successfully achieved the instrumental objectives of the CORE Act. The report also provided several recommendations for streamlining the program and suggested that the recycling incentive payment be examined to determine whether it could be modified to more successfully encourage the proper management of used oil.

In 2009, SB 546 made several significant changes to the CORE Act. In addition to the requirement for the lifecycle analysis and this report to the Legislature, SB 546 also made the following changes to the fees and incentives structure:

TABLE 2: CURRENT FEE AND INCENTIVE STRUCTURE

	Pre SB 546	**SB 546**
Manufacturer's Fee	$0.16 per gallon	• $0.26 per gallon 2010 – 2013 • $0.24 per gallon beginning January 1, 2014 • $0.12 per gallon for sale of re-refined lube oil
Recycling Incentive	$0.16 per gallon	• $0.40 per gallon on used oil collected from the public (paid to CCCs and passed on to customers upon request) • $0.16 per gallon for used oil generated by a CCC or industrial generator as a part of doing business
Re-Refined Production Incentive	NA	• $0.02 per gallon starting January 1, 2013 for production of re-refined base lube oil

Participants in the Used Oil Management System
The California used oil management system consists of a wide array of entities, from individuals to local agencies and large and small businesses.

- Manufacturers of lubricating oil are required to pay a fee for every quart of lubricating oil sold, transferred, or imported for use in California ($0.16 per gallon before 2010, $0.26 per gallon subsequent to the passage of SB 546). Revenues are deposited in the California Used Oil Recycling Fund to be spent only for activities specifically authorized by statute (PRC section 48653).

- California residents participate in the system by paying the fee when they purchase lubricating oil. Some residents, known as Do-It-Yourselfers (DIYs, currently estimated as accounting for about 16 percent of the lubricating oil sold) choose to change their own oil and can claim a recycling incentive of $0.40 per gallon ($0.16 prior to SB 546) when they deliver the used oil to a certified collection center.

- Certified used oil collection centers, as described above, consist primarily of oil change businesses, service shops, and auto parts stores. These entities accept used oil from the public free of charge and pay a rebate to the customer if requested. In return, the CCCs can submit a recycling incentive claim form for the used oil collected from the public ($0.40/gallon) and generated on-site ($0.16/gallon). Industrial generators (entities that generate used oil from the entity's own equipment) are also eligible to file claims and receive $0.16 per gallon for used lubricating oil recycled. In many locations, businesses or local government programs that accept used oil from the public choose not to become certified by the state due to staffing, cash flow, and paperwork requirements. These non-certified used oil collection centers also provide essential collection opportunities to targeted residents.

- Local government agencies are active participants in the used oil program. Most jurisdictions receive grant funding and operate their own programs, which include public education and outreach, CCC support, collection events, permanent and temporary household hazardous waste collection facilities, used oil filter collection, etc. Many local agencies actively promote source reduction through campaigns aimed at dispelling the 3,000 mile myth regarding oil change intervals.

- Used oil haulers are hazardous waste transporters that must be registered with DTSC prior to transporting used oil to a used oil recycling facility. In order to receive a recycling incentive payment, certified used oil collection centers and industrial generators must show that a registered transporter was used to transport the used oil.

- Transfer and storage facilities are also part of the state's used oil management program. During the used oil collection and management process, used oil haulers frequently transport used oil from various generators to transfer and/or storage facilities, as defined in HSC sections 25123.3(a)(3) and 25123.3(b), respectively. Transfer facilities hold hazardous waste shipments during the normal course of transportation. Storage facilities may hold the used oil for no more than 90 days before it is transferred to an end use destination.

- Ultimately, the used oil in the program is recycled by processors. In the state of California, collected oils that are tested and certified as being non-hazardous may end up in one of three main recycling routes: 1) recycled fuel oil production, wherein the used oil is filtered and dewatered and sold as a fuel oil or cutter stock, 2) distillation into a distillate fuel oil, usually blended with other fuels to be burned in marine engines and therefore often referred to as marine distillate oil, or 3) re-refining, in which the used oil is processed back into a base oil. Not all used oil is identical and not all used oil can be easily incorporated into all of the processing routes. Re-refining requires the highest quality feedstock while a facility that processes used oil into a distilled fuel typically has the ability to accept a wide range of feedstocks.
    - Recycled fuel oil production is the route that involves the least processing. Used oil is transported to a processing facility and stored in large tanks, where some natural settling

of sediments and evaporation of water occurs. It is then typically passed through a mesh strainer to remove large objects and some of the larger sediment particles. The oil is then heated in order to fully evaporate water content that enters the used oil stream during use and collection. At this point, it is ready for sale. The only inputs to the process are the natural gas or electricity used to heat the oil. No co-products are generated, but some wastewater and tank bottom sludge wastes are created. The wastewater is treated in a wastewater treatment facility, and the tank bottoms are managed according to their properties and the pertinent State and Federal laws regulating the management of that material.

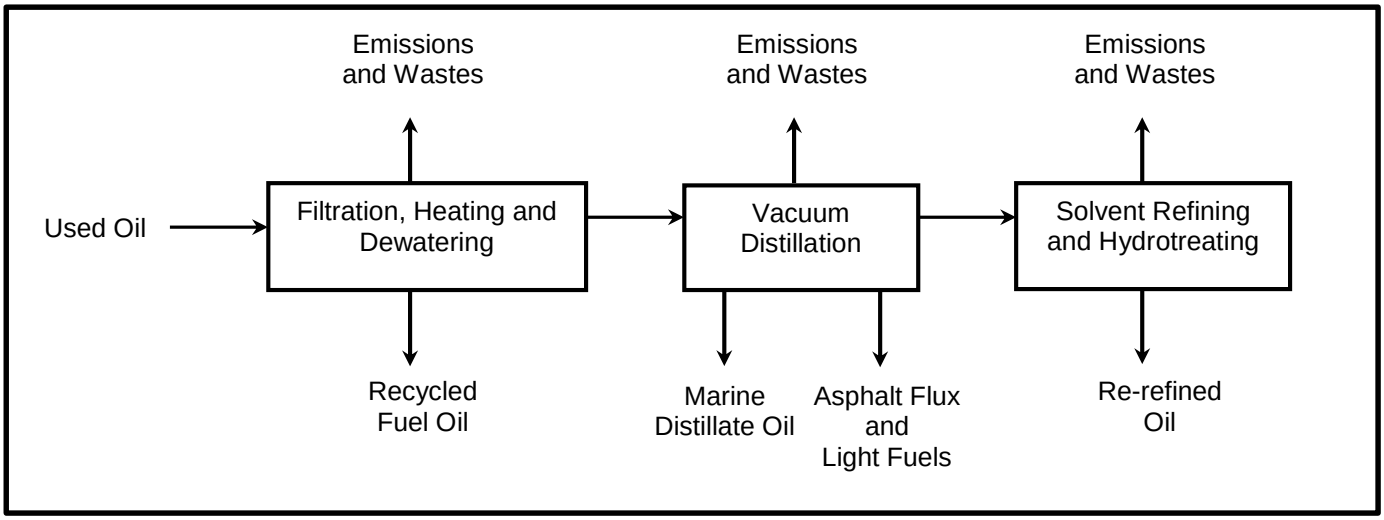
- Marine distillate oil production, like RFO production, produces a fuel that utilizes the energy content of used lubricating oil. However, MDO production involves significantly more processing steps. The same natural separation of water, oil, and tank bottoms occurs in storage tanks upon the oil's arrival at the MDO facility, after which the oil is heated and dewatered. The oil then passes through one or more distillation units, and different products are extracted. MDO, a middle-weight distillate fuel oil, accounts for the majority of the output. The MDO that is created from California's used oil stream is typically burned in commercial marine engines as a low sulfur cutter stock. A lighter fuel is also produced, which is referred to as "light ends." These are similar to a naphtha or gasoline and contain high levels of sulfur and halogens. Light ends are sold to facilities with high emission controls such as a waste incinerator or cement plants. The heavy bottom residuals are turned into an "asphalt flux." This is a high-viscosity product that is added to asphalt in road or roofing applications, where it is used to improve the quality of the final product due to the asphalt flux's lubricating qualities. Additionally, there is typically some amount of ethylene glycol from used antifreeze that has entered the used oil stream during the collection process. This fraction is removed and sold as a co-product. The various processing steps require energy inputs. In California, processors are most likely to use electricity or natural gas due to emission limits, although in other parts of the country processors may use some of the lighter co-products on-site to generate additional energy inputs. Some chemical inputs may be used in the treatment of the oil. Wastewater and solid waste are also generated from the processing. Wastewater is treated in a wastewater treatment facility, and solid wastes and sludge are managed according to their properties and the pertinent State and Federal laws regulating the management of that material.

- Re-refining into secondary base oil is the third primary disposition route for used oil. A re-refining facility turns the highest-quality fraction of the used oil stream back into lubricating base oil. As in the previous two routes, the oil is first filtered and dewatered. Like in MDO production, the oil is then passed through one or more distillation units. It may also be treated in a de-poisoning unit which removes some of the additives and contaminants that may negatively affect the machinery in the following processing steps. It is then passed through a wiped- or thin-film evaporator, which separates the light and heavy components, and the lube distillate and asphalt flux, respectively. The lube distillate fraction (also called vacuum gas oil) is subsequently treated in a process that exposes it to a proprietary catalyst and hot hydrogen gas. This process removes the majority of the sulfur, nitrogen, chlorine, and other remaining additives and contaminants. It also re-saturates the hydrocarbon molecules in order to improve the quality of the lubricant product. The re-refining process requires energy inputs such as

electricity and natural gas. As with the distillation process, facilities whose permits allow for it may also burn light fuels derived from the processing of the used oil. Plants may use various different chemical inputs to treat and de-poison the oil and hydrogen gas for the hydrotreatment process. The catalyst is replaced, on average, every seven years. As with MDO production, the heavy metals in the used oil are sequestered in the asphalt flux. Wastewater is treated either on or off-site, and tank bottoms are managed according to their properties and the pertinent State and Federal laws regulating the management of that material.

- End users of the secondary products are also participants in the used oil management system. This group includes but is not limited to electricity generators, asphalt plants, and cement kilns that purchase RFO, fuel blenders that may purchase MDO for use in marine shipping, and lubricant formulators that purchase re-refined base oil for eventual sale to lubricating oil manufacturers.

FIGURE 2: USED OIL PROCESSING FLOW CHART



Previous Studies/Research

Since the program's inception, CalRecycle has contracted for various research studies and awarded competitive grants for a multitude of projects, some of which are particularly relevant to this LCA study. Most of these reports can be found on the CalRecycle publications website: www.calrecycle.ca.gov/Publications.

1. "Comprehensive Assessment of California's Used Oil Program," California Polytechnic State University, San Luis Obispo, February 2005. This study was commissioned to provide a 10-year programmatic and performance review of the California Used Oil Recycling Program. Key findings concluded that after being in existence for a little more than 10 years, the program had succeeded in meeting the instrumental objectives specified in the CORE Act, including: implementing a manufacturer's fee and recycling incentive; establishing a network of certified and non-certified collection centers throughout the state that collects millions of gallons of used oil each year; developing a statewide used oil recycling outreach and education program; and

implementing a comprehensive grant program for local jurisdictions, nonprofit organizations, and private entities. The assessment also included recommendations to improve the program.

2. "Improving Used Oil Recycling in California," Lawrence Livermore National Laboratory, May 2008. This technical research study provides an independent assessment of California's 2008 used oil recycling market and provided recommendations to facilitate the recycling of used oil into re-refined base lube oil, primarily through market-driven forces. The report integrates market analysis, environmental assessment, regulatory reporting documents, numerous stakeholder interviews, and feasibility evaluations in order to form a set of recommendations for making improvements toward this goal. Based on direction from the Integrated Waste Management Board at the time, the report began with the presumption that re-refining used oil constitutes the "highest and best use" of used oil. Some of the recommendations in the report for increasing the recycling of used oil were incorporated into SB 546: Increase the current fee on lube oil sales, with the exception of sales of re-refined oil; reduce the fee on the sale of re-refined lubricating oil; and provide a monetary incentive to recycling facilities producing API-certified base lube oil. Another finding of the study is that marine distillate oil is a preferred alternative, in terms of environmental impact, to recycled fuel oil, which does not undergo distillation. Therefore, an additional recommendation (not included in SB 546) was to provide a smaller monetary incentive to facilities that produce industrial lubricant or MDO from California's used oil, provided they adhere to California's testing and waste management procedures.

3. "Evaluation of High Efficiency Oil Filters in the State Fleet," Department of Toxic Substances Control, 2008. This study explores the barriers to state agencies using high-efficiency oil filters in state fleets and recommended ways to overcome the barriers. The study included a field evaluation that demonstrated the performance of high-efficiency filter technology.

4. "To the Greatest Extent Possible: Do-It-Yourselfers and the Recovery of Used Oil and Filters," California State University, San Francisco, 2005. This report provides an in-depth look at Do-It-Yourself oil changers and includes targeted recommendations to improve used oil recycling by this group and to curb illegal disposal practices.

5. "Motivating the Wide Use of Re-Refined Motor Oil Among Public and Private Fleets in California," final grant report, Municipal Equipment and Maintenance Association, 2010. This competitive grant was awarded to a professional industry organization that worked with its members to increase their use of re-refined oil. The report included pre- and post-studies demonstrating an increase of 22 to 29 percent in customer use of re-refined oil.

6. Various public education, outreach, and research projects have been conducted over the past several years, including:
   - "Used Oil Source Reduction Study: Busting the 3,000-Mile Myth," 2007
   - "Community Based Social Marketing Pilot to Increase Do-It-Yourselfer Oil Recycling Rates," 2004
   - "Taking the Message to Recent Immigrants through English as a Second Language Classes: a CBSM Approach," 2007
   - "Proper Automotive Waste Management: Resource Manual," 2003
   - "California's Latino Independent Truckers: An Assessment of Used Oil Recycling, Attitudes, Practices, and Influencing Factors," 2006
   - "Re-Refined Oil Outreach: Encouraging Re-Refined Oil's Use at the Quick Lube," 2005

Methodology

This project required coordination among four main groups: CalRecycle, the lifecycle assessment (LCA) practitioner (University of California at Santa Barbara), the economic contractor (ICF International), and the stakeholder group. It also entailed independent peer reviews and a number of other supporting contracts and activities.

Stakeholder Process

The extensive stakeholder process utilized for this project was unique in the world of lifecycle assessments. The process proved highly beneficial in developing the scope and design of the lifecycle analysis, facilitating exchange of ideas and opinions, bringing varied expertise into the project, and assisting in data compilation. Stakeholders included, but were not limited to: primary petroleum refiners (American Petroleum Institute, Western States Petroleum Association, Chevron, Exxon, BP, Lubrizol, etc.); used oil re-refiners (Evergreen, Bango Oil, Heritage Crystal-Clean, Safety-Kleen, etc.); Demenno Kerdoon/World Oil (used oil distiller); the National Oil Recycler's Association (NORA); Californians Against Waste; and independent haulers, among others. A full list of participants can be found in Appendix B: List of Stakeholders.

CalRecycle engaged the services of the California State University at Sacramento (CSUS) to provide expert meeting facilitation services during the duration of this project. As part of these services, the meeting facilitator produced a report outlining the stakeholder process. Below are excerpts from the Used Oil Lifecycle Assessment Facilitator Report.

> ***Format:***
> *CalRecycle conducted a series of 11 Stakeholder Meetings held from January 2011 through July 2013. All Stakeholders Meetings were scheduled in cooperation with stakeholders to allow ample time for their attendance. The meetings were held exclusively in Sacramento (a complete list of participating stakeholders can be found in Appendix B). In addition, a webinar meeting was held in August 2013 for stakeholders to interact with contractors regarding their final reports, and in September 2013 to provide input on CalRecycle's draft preliminary findings. A special web portal was developed in cooperation with the California State University Sacramento (CSUS) College of Continuing Education to host all the meeting notices, registration of attendees, agendas, presentations, relevant documents (including documents developed by stakeholder subgroups), and meeting notes. Subgroups were created, based on self-selection, to work on key topics independent of scheduled stakeholder meetings that helped to frame discussions going forward. Over the course of 11 meetings and 31 months, discussions and deliberations by the stakeholders were thoughtful and comprehensive. Stakeholders were serious about their charge and worked to achieve the desired outcomes that reflect their collective consensus. Additional meetings were scheduled independent of the formally calendared stakeholder forums to allow stakeholders to further interact and share information.*
>
> *A primary objective in the project was to achieve high involvement among the stakeholders. Overall, the intent was to create a process that engaged stakeholders in a transparent environment while garnering greater understanding for the LCA project. Stakeholders were provided multiple opportunities to participate either individually, subgroups, and collectively. Information was shared with stakeholders who expressed an interest even though not all attended every scheduled meeting.*

Some of the limitations include:

- *Data collection*
- *Sensitivity of sharing data*
- *Multiple levels of collaboration*

Stakeholders were invited to share data about their organizations or help identify pertinent sources that may be used in the analysis. Because the source of some data was confidential, accepting it as reliable and valid was a concern. The use of Non-disclosure Agreements helped to mitigate some of those concerns. Finally, using multiple levels of collaboration was useful in keeping many stakeholders engaged. It was also challenging to manage the requests of so many stakeholders for more information while eliciting their support for participation and data sources. The multiple levels of collaboration did not appear to be a major limitation, but it does point out the need to communicate messages repeatedly and frequently.

Conclusions:

Several accomplishments are identified in the project:

- *Stakeholders engaged in the process to develop Scope of Work (SOW), design work, and identify data sources.*
- *Collaborative process*
- *Objectivity through multiple contractors*
- *Stakeholders vetted work of contractors*
- *Transparency*
- *Multiple opportunities to review and comment on data and information*

The initial stakeholder meeting began the process to develop the SOW, design how work was to be accomplished, and identify data sources. These items were constantly reviewed and vetted throughout the course of the project. This process allowed collaboration among stakeholders, consultants, and CalRecycle to ensure maximum participation. Further, stakeholders were allowed to review and critique the work of contractors. Objectivity was achieved through the use of multiple contractors who conducted the original analysis while other contractors validated the work. Finally, CalRecycle maintained transparency by availing information to stakeholders via multiple venues throughout the process. In essence, CalRecycle provided multiple venues and many opportunities for stakeholders to review and comment on the LCA project.

Overall, CalRecycle was very effective in conducting a comprehensive analysis that garnered greater understanding among stakeholders about the LCA project. Their effort to achieve collaboration and buy-in among stakeholders was evident during the 11 meetings. Stakeholders were very active in the discussions about the topics while offering suggestions to guide the process. In addition, the process was transparent throughout the project; all meeting notes, documents, and work were posted for review and edited by stakeholders. CalRecycle has successfully achieved its objectives for Phase I of the LCA.

Scope and System Boundaries

This section first describes the project scope, including the time frame for which the analyses were conducted, and then describes and explains why certain parameters were excluded from the analysis.

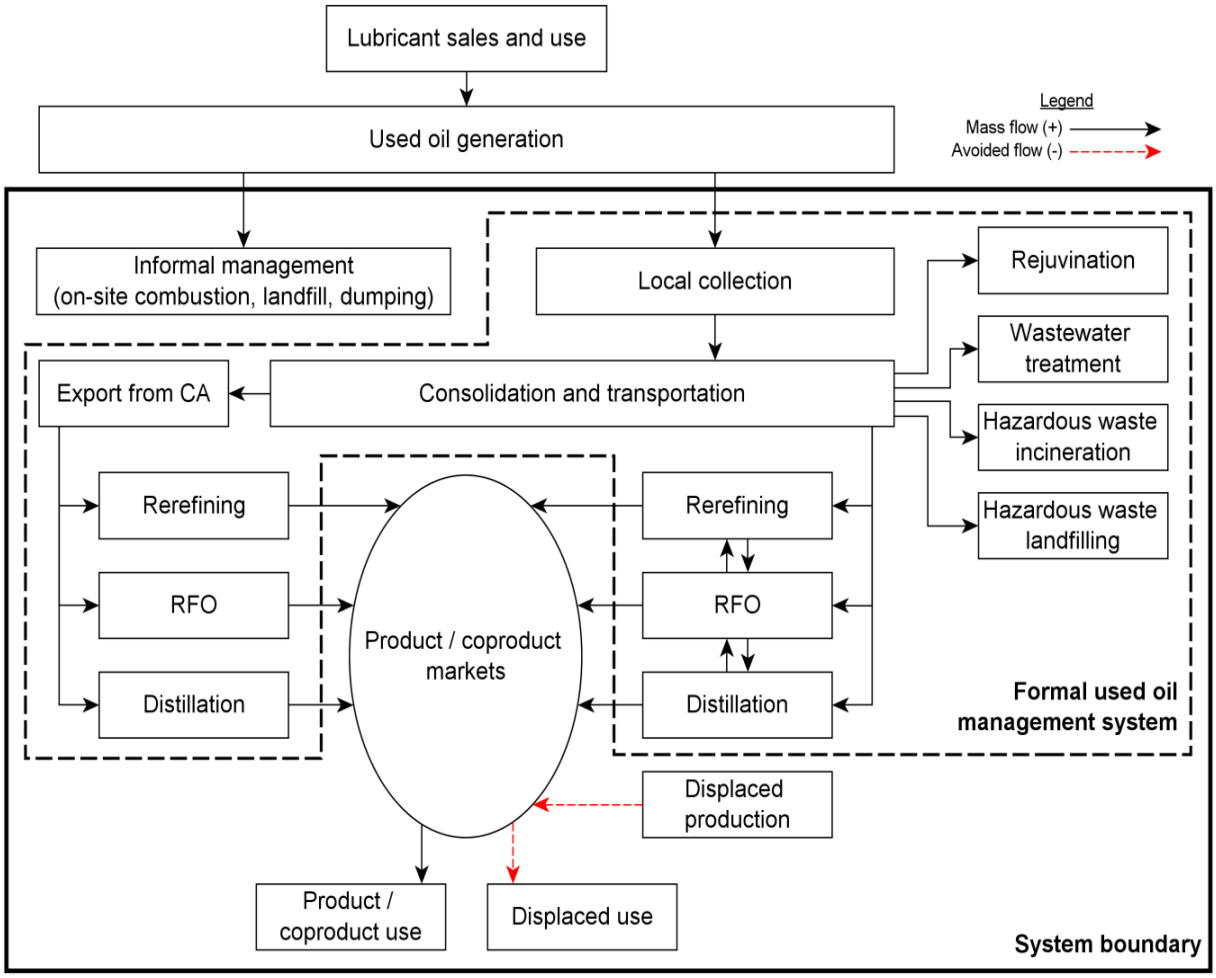
Overall, the studied product system manages the following used oil generated within California state boundaries: lubricating and industrial oils as defined in PRC section 3460 and HSC section 25250.1, as well as used dielectric oil (dielectric oils, which are highly refined mineral oils used as an insulator and coolant in transformers, are excluded from the statutory definitions of lubricating oil and industrial oil but are included in the used oil waste stream and therefore are included in the scope of this study). Used oil is generated when lubricating or industrial oil leaves its intended use phase in a collectable form. All possible fates of used oil generated in California have been included in the analysis. These include: improper disposal; on-site combustion; reprocessing into recycled fuel oil (RFO); reprocessing into distillate fuel oil (marine distillate oil, or MDO); re-refining into secondary base oil; and onsite rejuvenation. Effects on primary products competing in markets with secondary output products from used oil disposition are also within the scope of this study.

Lifecycle assessments typically begin with a description of the "functional unit" that will be analyzed. For this project, the function of the studied product system is the management of used oil generated in California, and the specific functional unit is defined as the management of all used oil generated in California during a calendar year. LCAs also define the time frame over which impacts are analyzed. For this study, the base year is calendar year 2010, and the overall time frame for the analysis is defined as a 20-year period beginning in the 2010 base year and ending in 2030 (i.e., the years 2010 through 2030 represent the "study period"). This baseline was established to show the environmental and economic implications of the used oil management system in California under the current regulatory scheme and to provide a reference point with which to compare hypothetical policy scenarios.

Given this definition of functional unit and the definitions of baseline and study period, this LCA entailed inventorying the specific environmental impacts (called the inventory model) associated with the management of used oil. The inventory model for the calendar year 2010 is called the "Base Year Model." The continued operation of the system under "business as usual" through 2030 (i.e., with no policy or capacity changes) is referred to as the "Baseline Scenario." Potential changes in these environmental impacts that might result from changes in policy and/or capacity then were assessed through scenario modeling, which entails re-running the LCA inventory of potential impacts to reflect variables such as changes in disposition routes. The resulting inventory models or "scenarios" extend over the study period to 2030.

Figure 3 shows a process flow diagram of the lifecycle assessment of used oil management in California. As described above, in the context of this LCA, California's used oil management system begins with the generation of collectable used oil within California state boundaries. Processes upstream of used oil generation are outside the boundaries of the studied system.

FIGURE 3: PROCESS FLOW DIAGRAM OF THE LIFECYCLE ASSESSMENT



The study's system boundary was chosen to begin with the generation of used oil, in accordance with the statutory requirements of SB 546 as well as standard practice in LCAs of waste management. Used oil generation was defined as occurring when the oil is drained from its point of use. This interpretation is consistent with state and federal laws regarding solid wastes. Thus, lifecycle stages prior to used oil generation were excluded. The study follows the generated collectable used oil downstream until it reaches the natural environment, is consumed (burned, combusted in the engine, dripped, or absorbed by rags or other materials), or is reprocessed into secondary products. The system boundary further includes the use of the secondary products and their market effects, in particular their interaction with competing products. The market effect is modeled as displaced production and displaced use of the products that are being substituted by the secondary products from used oil disposition. Displaced production and use is modeled for all primary products that are understood to compete with the secondary products from used oil re-refining into base oil, used oil distillation into marine distillate oil, conversion of used oil into recycled fuel oil, and used oil combustion at the site of its generation. Displaced production and use is not modeled for dielectric oil rejuvenation, which is regarded as a lifetime extension. Lubricant sales quantities are used to determine the amount of collectable oil in the material flow analysis (MFA) but are out of scope for impact assessment.

The studied used oil management system is divided into informal and formal management subsystems. The informal management system consists of the following components:

- Dumping: The draining of used oil directly onto soil or into waterways
- Landfill: The disposal of used oil into the regular solid waste stream
- On-site combustion: The use of used oil as fuel by the generator at the site of generation

The formal used oil management system can be divided into the following stages:

- Collection and waste disposal: The storage and transportation of all collected oil, i.e. oil that is retrieved from a certified collection center or from a facility by a certified hauler; and the direct disposal of used oil not suited to be processed due to its off-specification nature or hazardous components
- Used oil reprocessing: Reprocessing of used oil into RFO, MDO, or re-refined base oil
- Use of secondary products: The use of all secondary products, such as combustion of MDO in marine engines or of RFO in asphalt kilns
- Displaced primary production: The avoided production of primary products that are displaced due to market interactions with secondary products

Other potentially significant contributors to lifecycle impacts were systematically omitted because they were expected to be consistent across all comparison cases, or because the available inventory data were inadequate to reflect potential differences in comparison cases. The following were excluded from the system boundaries:

- Primary lubricant production and sales
- The primary use phase of lubricating oils prior to becoming used oil
- Impacts incurred during the use phase, including those from drips, leaks, and inadvertent combustion
- The use and end of life of re-refined base oil, asphalt additives, and ethylene glycol; and avoided use and end of life of displaced primary analogues. These phases of these secondary and primary products are understood to be identical and thus cancel out
- Infrastructure and capital goods, except for landfills
- The management of used oil as a hazardous waste

Four of the topics listed above were discussed at great length during the stakeholder meetings: primary lubricant production and sales, the primary use phase of lubricating oils prior to becoming used oil, impacts incurred during the use phase, and the management of used oil as a hazardous waste. While no consensus was reached on these issues, CalRecycle made decisions ultimately to keep these topics out of the scope of this project. The production and use phases of lubricating oils prior to becoming used oil was determined to be explicitly excluded from the definition of used oil and the direction given in SB 546. The impacts that are incurred during the use phase are likely included (for passenger vehicle and heavy-duty lubricating oils, at least) in the uncollected oil model as those oils have virtually no technically uncollectable oil.

Exclusion of Hazardous Waste Management of Used Oil From Scope of Study

Used oil must be managed as a hazardous waste in California; the collection and management of used oil are subject to regulations under the authority of DTSC. Health and Safety Code section 25250.1 defines used oil and the conditions for managing hazardous waste. A subset of the stakeholder group argued that

this lifecycle analysis project should include a modeling of the used oil management system if the designation of used oil as hazardous waste were removed. These stakeholders assert that the costs and burdens of complying with hazardous waste management requirements are key contributors to the lower value of used oil in California compared to the rest of the country. Some used oil haulers and recyclers stated that they operate at a competitive disadvantage compared to out-of-state haulers and recyclers due to various requirements. Specific burdens described by stakeholders include but are not limited to: storage and accumulation limits, testing requirements (costs of laboratory testing and of "down time" waiting for test results), manifest tracking requirements, and the requirement to obtain and regularly renew an EPA identification number.

After extensive discussion at stakeholder workshops and consultation with CalRecycle legal staff and DTSC, CalRecycle issued a memo in June 2011 stating in part: "CalRecycle has decided not to include the regulatory status of used oil as a hazardous waste as a component to be analyzed in its Used Oil Lifecycle Assessment of environmental impacts and the associated economic analysis pursuant to Senate Bill 546." The designation of used oil as a hazardous waste has been a core tenant of the used oil management system in California since 1986, and CalRecycle did not believe it was the intent of the Legislature to evaluate a change in its designation. A separate study of this issue could be conducted in the future if such direction is provided by the Legislature.

Lifecycle Assessment

California Public Resources Code section 48651.5(b)(1)(A) requires that CalRecycle contract with a third party to conduct a lifecycle analysis. The University of California at Santa Barbara (UCSB) was chosen as the LCA practitioner.

The LCA associated with this project is comprised of four distinct models:

- Lifecycle assessment (or inventory) model
- Material flow model
- Improper disposal model
- Combustion model

These four models were created in order to give a more accurate picture of the environmental impacts of the baseline used oil management system as well as the potential changes to those impacts based on hypothetical policy scenarios.

One issue of concern to some stakeholders was CalRecycle's decision to use what is known as a "consequential" approach to the LCA, as opposed to an "attributional" approach. There are several important differences between these approaches, which were discussed during the initial meetings with the contractors and stakeholders. CalRecycle and its LCA contractor deemed the consequential approach as best-suited to the particular issues and questions that needed to be addressed. Attributional LCA attempts to identify environmental burdens associated with the production and use of a product, service or process at a point in time (typically the recent past). In contrast, consequential LCA attempts to identify the environmental burdens of a decision or a proposed change in a system under study (the consequences of that change), which means that market and economic implications of a decision often must be taken into account. An attributional LCA expands the boundaries of the study to include products and processes to ensure an equivalent functional unit, while a consequential LCA adds the consequences of changes to accomplish the same equivalent functional unit. Attributional LCA does not utilize the concept of avoided burden and therefore cannot show a negative environmental impact (as is often the case in recycling

systems), while consequential LCA does show negative environmental impacts when the avoided burdens exceed the incurred burdens. These issues, along with many others, were discussed at length at the stakeholder meetings and through formal stakeholder comments. CalRecycle's responses to stakeholder comments, including more detailed responses on this issue, can be found on CalRecycle's website.[4]

Due to the fact that an LCA's usefulness is limited by the quality of data used, CalRecycle and its contractors exerted significant effort to gather existing data and obtain new data. Data was gathered by exploring the existing body of literature, by requesting it from the industry experts represented in the CalRecycle stakeholder group, by entering into contracts with recognized experts in the field to provide data, and by generating new data via primary laboratory analysis.

For example, accurately determining the collection rate for used oil requires knowing both the amount of oil available for collection and the amount of oil that is collected. The amount of oil available for collection is based on the total sales and the amount of oil that is consumed during use (and therefore unavailable for collection). This "loss-in-use" rate has historically been very difficult to determine, and estimates vary dramatically. In order to better understand how much additional oil is available to be collected as well as to be able to accurately assess the environmental impacts of uncollected oil, a much more accurate estimate for this "loss-in-use" rate was needed.

After consultation with industry expert members of the stakeholder group, it was determined that only one company maintained records of sufficient scope and reliability to be used for this purpose. CalRecycle purchased a report prepared by this company (Kline, Inc.) that not only provided details on oil sales in California (lubricating and industrial) but also provided estimates for loss rates for each category of oil. This report provided loss rates that are both "technical," meaning it cannot be recovered, and "practical," meaning it could be recovered and legally recycled but is not likely to be due to other reasons. The data provided in this report allowed a much more detailed analysis of the uncollected oil and of which sectors were likely to be generating oil that could be collected but is not currently being collected.

In addition, some of the major areas of disagreement concerned data regarding combustion of recycled fuel oil, assumptions concerning displaced products, toxicity impact assessments, and data concerning uncollected oil. There were also differences of opinions on the basic modeling conducted by the contractors and the sources of data, some of which were necessarily confidential. These issues are further discussed in the Results and Key Findings section and in Appendix A: Interpretation Issues. Each of the contractor reports[5] also details the assumptions made in their analyses.

LCA Critical Review

The International Organization for Standardization (ISO) has established a set of protocols for the completion of lifecycle assessments. These standards are detailed in ISO 14040 and ISO 14044.

ISO 14040 also sets forth a process for performing an external professional review of LCA, which it refers to as a "critical review." Below is an excerpt from ISO 14040 section 7 describing a critical review:

[4] http://www.calrecycle.ca.gov/usedoil/LCAProject/default.htm

[5] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1465

"Critical review is a process to verify whether an LCA has met the requirements for methodology, data, interpretation and reporting and whether it is consistent with the principles. In general, critical reviews of an LCA may utilize any of the review options outlined [below]. A critical review can neither verify nor validate the goals that are chosen for an LCA by the study commissioner, nor the ways in which the LCA results are used."

"A critical review may facilitate understanding and enhance the credibility of LCA, for example by involving interested parties. The use of LCA results to support comparative assertions raises special concerns and requires critical review, since this application is likely to affect interested parties that are external to the LCA. However, the fact that a critical review has been conducted should in no way imply an endorsement of any comparative assertion that is based on an LCA study."

CalRecycle contracted with six entities, including a review chair and five review panel members, to work together to provide a thorough and unbiased critical review of the procedure used in performing this LCA. The full critical review report is available, along with the final LCA report, for reference on the CalRecycle website.[6]

Economic Analysis

California Public Resources Code section 48651.5(b)(1)(C) requires that CalRecycle evaluate the effects of a number of economic changes to the California Oil Recovery Enhancement Act, namely the testing requirements for out-of-state transport of used oil, the tiered fee on lubricating oil sold in California, and the tiered incentive payments. In addition to these requirements and after receiving input from the stakeholder group related to the scope of the project, CalRecycle decided to include a comprehensive economic analysis to better understand the total effects of changes on the used oil management system in California. CalRecycle further decided that this analysis needed to be integrated closely with the LCA to ensure their results were compatible. To accomplish this, CalRecycle conducted a competitive bid process and subsequently awarded a contract to ICF International based on its proposed implementation strategy.

The inclusion and integration of a comprehensive economic analysis with a traditional lifecycle analysis has not been attempted on this scale before, and it required the development of new modeling approaches. Because of the simultaneous complexity and relative small scale of the used oil market, the use of existing "off the shelf" economic models would be sufficient for this project. This project required the examination of a relatively small sector of a much larger industry (the petroleum industry). The used oil industry is comprised of a large number of individual entities in relation to its overall size. Most of the economic models available "off the shelf" do not distinguish industries into such small sectors and therefore would not be able to identify impacts on the various entities involved, such as collection centers or haulers. The larger-scale economic models are better equipped at analyzing larger industry sectors as well as at determining the distributional impacts (those "collateral" impacts outside the industry being directly analyzed). For this reason, the economic analysis was split into two distinct sections to address the unique details of the used oil market in California and the lack of an existing adequate economic model. The two sections of the economic analysis are the direct impacts model (DIM) and the cost benefits model and distribution impacts analysis (CBA).

[6] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1468

The Direct Impacts Model (DIM)
This model is used to predict how the used oil market in California is likely to respond to changes in both economic forces and behavioral forces. Economic forces that are included in this analysis include exogenous market forces such as the price of crude oil, the number of miles that people drive their cars and number of miles between oil changes, and policy-related forces such as fees, incentives, and other regulatory requirements. Behavioral forces are included for those activities in which behavior is influenced by multiple factors, one of which may be economics. This can be best exemplified by the case of a Do-It-Yourself (DIY) oil changer whose decision to return their oil for recycling is influenced in part by the monetary incentives offered for doing so but also by convenience and the desire to be a responsible member of society. It is important to understand that while the DIM does attempt to model these behavioral forces, such behavioral forces are better addressed by behavioral science experts. In the absence of a model that incorporates behavioral research into the economic model, the contractor instead adjusted a variable called "price elasticity," which explains the responsiveness of an entity such as a consumer to a change in price. This price elasticity was adjusted to a low value to take into account the observations made by local government staff as well as operators of certified collection centers. The price elasticity value was then tested at a much lower value (a sensitivity analysis) to better understand how different values would affect the results (also see "Limitations of the Study" section).

Some stakeholders raised concerns about the ability of the model to "backcast" historical conditions. Many recent years included some of the worst economic conditions since the Great Depression; only a few very recent years were representative of a more "normal" economic condition. The years for which the model was calibrated were the more recent years that represent a "business-as-usual" condition. This was done so that the model would be able to accurately predict future conditions in what would realistically be assumed to be closer to "normal" economic times. The year 2010 was chosen as the "base year" for this and all other aspects of this analysis, as it was the most recent year for which full datasets existed at the time of the analysis.

The Cost Benefit Model and Distributional Impacts Analysis (also known as "Cost Benefit Analysis" or CBA)
This model uses the outputs of the DIM and the LCA. The CBA then models the effects of all the changes made in the DIM on larger groupings of sectors, such as hospitality or construction. The distributional impacts analysis portion shows the effects of changes on the used oil management system to the rest of the economy, which would show, for example, jobs created in the construction industry if new oil processing facilities were to be constructed. It would even attempt to show the number of restaurant and housing jobs created in response to the additional construction jobs. The CBA also attempts to monetize environmental impacts reported from the LCA.

Due to the baseline covering 20 years beginning in 2010, it also was necessary to model the expected changes in lubricating oil demand, or sales. Lubricating oil demand is dependent on a number of factors, including oil formulation, recommended drain intervals, the number of miles driven on average per vehicle per year, the number of vehicles in use, and the age of the vehicle. With input from the stakeholder group and by referencing other forecast models, the economic contractors determined that the most likely trend for lubricating oil demand over the 20-year baseline period is a slightly decreasing one. The demand of new oil for each year of the 20-year baseline period was also determined.

Finally, while no ISO standard exists for the economic analysis and review as does for the LCA, CalRecycle used an external review panel to provide an unbiased review of the economic analysis, as discussed in the next section.

Economic Peer Review

There is no international standard for performing economic analyses of these kinds as there is for the LCA, nor is there a standard for the completion of a formal review process. However, peer reviews are very common in the field of economics, and such a review was undertaken for the economic portion of this project. The economic review was overseen by the chair of the Economics Department at California State University at Long Beach. The review was conducted in two phases: the first phase was performed on a late draft of the model construction and reports, and the second was performed on the final versions of the models and reports. The review of the late draft was conducted to provide expert feedback regarding any potential issues that could be addressed prior to completing the final reports. The review of the final models and reports serves as expert opinion regarding the appropriate use of economic theory and techniques in analyzing the used oil system in California.

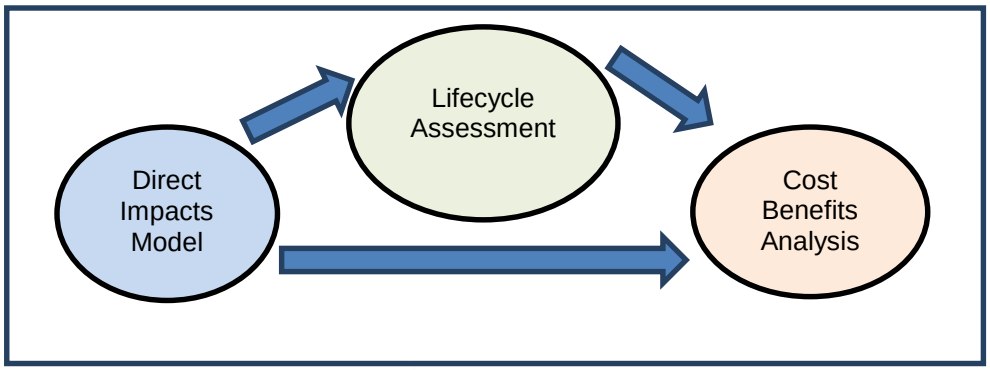
Model Integration

In order for the three models to function in a manner that provides useful results and ensures consistency, a mechanism for model integration and iteration was necessary. To accomplish this, the contractors and stakeholder group were consulted to create a mechanism that would be most beneficial to the project. The University of California at Santa Barbara included the economic peer reviewer as a subcontractor to serve as an adviser during the process.

Figure 4 below diagrams the model integration mechanism used in this project. It begins with the direct impacts model (DIM). The DIM uses economic market forces to determine what changes in the used oil market are likely to occur based on a hypothetical policy change. These include changes to the volume of oil collected, the amount of oil brought to the various collection locations, and the amount of collected oil that flows to various disposition routes. The new used oil flow data is fed into the LCA model. These new flows are used to determine new environmental impacts. Finally, information from the DIM and the LCA are fed into the cost benefit analysis model. The CBA uses information from the DIM and an economic modeling program called Policy Insight by Regional Economic Models, Inc. (REMI) to determine which sectors in the economy are affected and to what degrees; it also determines job impacts. The CBA also uses a process called “benefits transfer” to attempt to assign a monetary value to the environmental emissions as reported by the LCA.

The LCA and economic models were then used in tandem to determine the likely economic and environmental changes that could be expected by implementing various hypothetical policy changes in California. These were evaluated as individual changes or “levers” in an effort to isolate the effects of individual actions.

FIGURE 4: MODEL INTEGRATION MECHANISM



Results and Key Findings

The four key analyses for this project consisted of the LCA baseline, economic baseline, hypothetical policy scenarios, and extreme disposition scenarios. The results of these analyses are presented here in five sections:

- General Overall Findings—This section shows general results related to the project as a whole rather than specific to the LCA or economic analyses themselves.
- LCA Baseline Results—The lifecycle assessment describes the environmental emissions associated with the baseline condition and the 20-year period beginning in 2010 assuming all California policy factors remain constant.
- Economic Baseline Results—The economic models (the direct impacts model and the cost benefits model) describe the economic condition associated with the same baseline condition that was used for the LCA.
- Hypothetical Policy Scenarios—The LCA and economic models were then used in tandem to determine the likely economic and environmental changes that could be expected by implementing various hypothetical policy changes in California. These were evaluated as individual changes or "levers" in an effort to isolate the effects of individual actions. Many of the differences seen during the examination of these policy scenarios were very small and difficult to distinguish. These scenarios also include statutorily required scenarios and testing results.
- "Disposition" Scenario Results—The LCA model alone was used to describe four "extreme" disposition scenarios under which all of the used oil generated is routed to a single disposition route. This takes the relatively small differences seen in the policy scenarios and amplifies them to allow a more thorough analysis of those differences.

General Overall Findings

While most of the results are associated specifically with one of the four categories listed above, there are also some more general findings. For example, this project provided greater clarity on the amount of oil sold in California as well as the amount available for collection after use. Estimates were made to more accurately model future demand for lubricating oils, and specific gaps in knowledge that prevent focused efforts in used oil collection were identified. One general finding is that the most likely trend for lubricating oil demand over the 20-year baseline period is a slightly decreasing one.

Several general findings are related to the changes in fee and incentive structure as specified in SB 546, which were intended to increase the collection and proper management of used oil. SB 546 made the following changes:

- Manufacturer Fees—The manufacturer fee was increased to $0.26 per gallon of lubricating oil sold or transferred in California; the fee will be reduced to $0.24 per gallon on Jan. 1, 2014. The additional $0.02 per gallon was directed to the implementation of the comprehensive lifecycle analysis that is the primary subject of this report. SB 546 also established a reduced fee of $0.12 per gallon for the sale of finished lubricant containing at least 70 percent re-refined base lubricant.
- Incentive Payments—Incentive payments to certified collection centers were increased to $0.40 per gallon of used oil collected from the public. The CCCs in turn pay $0.40 per gallon to the generator of the used oil upon request. CCCs that generate used oil as part of their business model (i.e., servicing vehicles) are paid $0.16 per gallon for oil that is recycled. Industrial generators can also receive $0.16 per gallon for used oil generated from their own equipment. In order to encourage processing of used oil into re-refined lubricating oil, SB 546 also established a $0.02

per gallon incentive payment directly to producers of re-refined base lube oil. This additional incentive began Jan. 1, 2013.

- Grants and Payments—SB 546 specified that CalRecycle provide $11 million annually in payments to local jurisdictions on a per capita basis for the development and support of local used oil collection programs.

Uncollected oil represents a significant volume of oil and is a driver for many environmental impacts as well as economic forces. However, uncollected oil is poorly accounted for, which makes it difficult to understand the economic forces that motivate the generators of that used oil. This information has historically been difficult to obtain; however, a few key pieces of information are less uncertain. The used oil lifecycle assessment and associated economic analyses suggest that some of the existing financial mechanisms are not ideally tuned to produce the desired results. For example:

- As a result of the increase in the incentive payments introduced in SB 546, CalRecycle anticipated that the number of certified used oil collection centers and the volume of used oil collected would increase. It was thought that the CCCs would expand their outreach efforts to their customers about used oil collection and recycling in order to attract more used oil from the public and increase their revenue. Although the incentives have only been in place for three years, no appreciable increase in volumes or in the number CCCs has occurred.
- The reduced fees for re-refined oil, intended to increase used oil re-refining, have not resulted in increased used oil re-refining.
- The increase in the Do-It-Yourself (DIY) incentive payment amount from $0.16 per gallon to $0.40 per gallon has not increased the amount of DIY oil collected or the total amount of used oil collected.
- Approximately 95 percent of DIY oil changers have reported (via informal surveys conducted by local government used oil program managers) that the incentive payment is not a motivating factor in their decision to recycle their oil. Other factors such as convenient collection opportunities, cleanliness, and an understanding of the environmental impacts of improper used oil disposal are more important motivators for DIYers to properly manage their used oil.
- The re-refining incentive payment of $0.02 per gallon began on Jan. 1, 2013, and while no change in re-refining activity is expected due to this incentive (based on the economic analysis performed), there is very little data.
- The out-of-state transportation testing requirements have not been shown to have resulted in fewer gallons of used oil leaving California, nor have they resulted in cleaner used oil leaving California.
- Do-It-For-Me (DIFM) shops seem to operate in accordance with the law. These entities are often highly regulated and must meet many other requirements related to their handling of hazardous materials. It is possible that some small or remote facilities are not complying with used oil handling requirements, but no data exist to verify this.
- Industrial generators seem to operate in accordance with the law. These entities are often highly regulated and must meet many other requirements related to their handling of hazardous materials. It is possible that some small or remote facilities are not complying with the used oil handling requirements, but no data exist to verify this. Very little is known about this group.
- Generators of industrial oil are nearly wholly unknown as they have not been included in the fee/incentive program currently in place for lubricating oils. A great deal more data has been gathered regarding industrial oil as a result of this study.

The direct impacts model portion of the economic analysis indicated that various hypothetical scenarios might result in an increase in lubricating oil and/or industrial oil collection. However, these results depend

on assumptions made about price elasticity, which refers to the relationship between price and behavior. A high level of uncertainty is associated with price elasticity assumptions, as further explained in the "Economic Analysis" section, and as a result sensitivity analysis was performed using assumptions of price elasticities of 0.2 and 0.02. Using a price elasticity of 0.2 suggests a low correlation between price and response (i.e., it suggests that people are not motivated very much by the incentive), while a price elasticity of 0.02 suggests even less (nearly zero) correlation between price and response. Further discussion of price elasticities can be found in the "Limitations of this Study" section.

Many of the changes to the fees and incentives have not been in effect long enough to reliably make definitive statements regarding their ultimate effect; i.e. re-refined incentive payment. Market forces beyond the statutory changes (such as price paid for used oil out of state), may have also played a role. Significant additional data is still needed regarding used oil generator behavior and motivation, along with location and ultimate disposition of uncollected oil.

LCA Baseline Results

The lifecycle assessment model reports results as quantities of substances released to the environment. These data are input into existing impact characterization models (previously developed by other entities not associated with this study) to generate environmental impact scores. An example of this is Global Warming Potential. Many substances contribute to global warming, each to a varying degree; these include substances like carbon dioxide and methane. Each of these substances is added up, factoring in their specific degree of contribution, to generate a score that has been normalized to assist in interpretation. In the case of the Global Warming Potential environmental indicator, for example, the results are presented in terms of carbon dioxide equivalents.

In particular, the direct impacts model was used to create material flow profiles for each of the 20 years of the baseline period. This was necessary for the LCA model to generate new outputs for future years and to establish the expected environmental impacts of the system as it currently exists (without any further policy changes). The DIM analysis indicates that many of the LCA environmental impact indicator results are driven by a few or even a single elementary flow. This is particularly true for the toxicity impact categories:

1. Zinc is the primary driver for toxicity and non-cancer human health impacts. This is due in large part to the way zinc is characterized in USEtox, which is the characterization model used, and because widely accepted values regarding the toxicity of this substance are not available (see "Lack of Reliable and Comprehensive Data" in Appendix A.).
2. Phosphorus is the primary driver for eutrophication impacts. This is influenced largely by assumptions made regarding phosphorus content in used oil and phosphorus retention rates during combustion.
    a. Greater information regarding phosphorus content is being gathered via used oil laboratory testing.
    b. A large-scale, detailed combustion study would be required to gain further accuracy regarding retention rates of phosphorus (among other combustion-related emissions).
3. Non-methane volatile organic compounds are the primary driver for cancer-related human health impacts. Little data is available on these emissions; if impacts in the category are of interest, then significant further research is needed.

The lifecycle assessment report[7] also demonstrated that while additional effort is currently being undertaken to gather more complete, accurate, and current used oil composition data, different used oil compositions have a relatively small impact on the results: While different used oil compositions may change the exact numerical results, they do not lead to different rank ordering of disposition routes in any impact category.

In order to generate these baseline results, a number of assumptions needed to be made in order to address data gaps and data variation. The most crucial assumptions are summarized here (also see Appendix A: Interpretation Issues and Contractor Reports[8]). In particular, CalRecycle and its contractors acknowledge that data gaps and assumptions regarding emissions and retention rates, displacement, and natural gas leakage rates create uncertainty that can have significant impacts. For example:

1. Emission and retention rates vary considerably based on combustion technology, emission control technology, and fuel composition. While some additional work is currently being performed to gather additional fuel composition data, greater detail regarding combustion technologies and emissions controls were not obtainable during the course of this study. CalRecycle and its contractors were not able to find any sources for this data within or outside the stakeholder group. As a result, CalRecycle and its contractors made assumptions regarding emissions and retention rates based on the best available information, which included stakeholder recommendations as well as the limited available published data. For example, because little to no data exist comparing specific emission control technologies with emissions reduction based on fuel composition, the contractors created three "cases" that represent three ranges (high, medium, and low) of emissions control efficiencies. These three ranges were tested for sensitivity and applied based on feedback obtained from stakeholder discussions.
2. Because natural gas is assumed to displace RFO combustion, the assumptions regarding the amount of natural gas leaked during transmission can alter the rank ordering of the disposition routes. This matter was investigated, and the model was adjusted based on the best available data for estimates related to natural gas leakage rates. The numbers used in the final report are unlikely to be further enhanced with additional research.
3. Various assumptions regarding the fuel that RFO displaces can impact the rank ordering of the disposition routes. After speaking with members of the stakeholder group as well as other industry experts, the displacement assumptions used in the final report were determined to be the most accurate available. Products were chosen if they were likely to be displaced after expert input.
4. Changes to reverse logistics (the process of collecting used oil and transporting it to a facility for processing) assumptions are not large enough to influence overall LCA results.
5. Assumptions about the fate of uncollected used oil can have considerable impacts on the results. These assumptions include how much of the uncollected used oil is dumped on the ground, dumped in the water, combusted on-site, or landfilled. Assumptions are also made on the volume of uncollected used oil; since we have no direct data regarding this volume, the study assumes that the difference between generated used oil (a calculated value based on a contract with Kline) and collected used oil is uncollected.

[7] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1465

[8] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1467

These assumptions represent the best approximation available to CalRecycle and its contractors. Details regarding all assumptions are available in the various contractors' reports. The values of these assumptions were tested using sensitivity analysis to determine the level of influence that changes to these assumptions have on the final results of the analysis. These assumptions and sensitivity analyses are described in greater detail within the body of the LCA report.

Economic Baseline Results

The economic analysis was split into two main categories or models: The direct impacts model was created to model the impacts and economic behavior of the various entities involved in the California used oil management system, while the cost benefits analysis utilized a regional impacts model called REMI to estimate the larger regional economic impacts, including impacts on employment.

The economic analyses suggest that incentives, whether given to generators or processors, have little effect on collection rates or processing routes when applied at reasonable levels (presumably, incentives in excess of $5 to $10 per gallon would have larger impacts, but these were considered outside the realm of reasonableness and therefore excluded from these analyses). Greater impacts can be seen when market prices are increased for used oil across all generators, oil types, and processing routes. While no specific mechanisms were included in this study for increasing the market price of used oil in California, one recommendation is offered by CalRecycle as Policy Option 7 below. A number of stakeholders mentioned that the value of used oil in California is lower than in other places within the United States and suggested that additional research be completed to determine the cause.

The cost benefit analysis helped to show what areas of the economy would be impacted and to what degree under a number of altered policy scenarios. This information is important to ensure that unintended economic harm is not inflicted on an industry in the course of protecting the environment. The CBA showed that in most cases, the economic impacts of various policy options would be minor. In the few cases in which more significant economic impacts are seen, those impacts are positive.

The concept of "external monetization" or "benefits transfer" attempts to assign a monetary value on environmental emissions. This methodology was utilized in this study, and the results are presented in the CBA. However, this methodology contained a large number of omissions, which resulted in CalRecycle choosing not to use them in making policy recommendations. There are currently acceptable valuations for very few environmental emissions (all of which are emissions to air), which result in a skewed valuation. This makes the external monetization results too difficult to interpret reliably.

Hypothetical Policy Scenarios

In order to better understand how potential changes to used oil management policy would affect the system, a number of hypothetical policy scenarios were created and their likely effects analyzed. This was used in order to better understand how each of the likely mechanisms, or "levers," would affect the system rather than to act as anticipated policy recommendations. The results of these hypothetical policy scenarios were used to inform CalRecycle in developing policy options and recommendations.

The policy scenarios are described below in Table 3.

TABLE 3: HYPOTHETICAL POLICY SCENARIOS

Scenario #	Description
1	Adjust DIY used lube oil recycling incentive payment from $0.40 per gallon to $0.80 per gallon. Sensitivity analysis was performed to determine the effect of price elasticity assumptions.
2	Adjust non-DIY used lube oil recycling incentive from $0.16 per gallon to $0.56 per gallon. Sensitivity analysis was performed to determine the effect of price elasticity assumptions.
3	Create a new used industrial oil recycling incentive and provide an incentive of $0.40 per gallon. Sensitivity analysis was performed to determine the effect of price elasticity assumptions.
4	Increase the market value of used oil collected in California from its current level of $0.30 per gallon on average to $0.70 per gallon. Sensitivity analysis was performed to determine the effect of price elasticity assumptions.
5	Adjust differential between manufacturer's fee paid on virgin lube relative to fee paid on lube from re-refined base oil, by assuming a reduction in the fee for oil made from re-refined base lube from $0.12 per gallon to $0.02 per gallon while maintaining the fee for virgin oil at the current rate of $0.24 per gallon.
6	Adjust re-refining incentive by increasing the incentive paid to re-refiners from its current value of $0.02 per gallon to $0.12 per gallon.
7	Create recovered light fuel/MDO incentive in the amount of $0.10 per gallon. There is currently no incentive for this product.
8	Create recovered fuel oil incentive in the amount of $0.10 per gallon. There is currently no incentive for this product.
Statutorily Mandated Scenarios	
9	Evaluate impacts of tiered fee structure by modeling a return to $0.16 per gallon on all oil rather than the current structure of $0.24 per gallon for virgin lubricants and $0.12 per gallon for re-refined lubricants.
10	Evaluate impacts of tiered incentive payments by modeling a return to $0.16 per gallon incentive for all generators rather than the current structure of $0.40 per gallon for DIY generators and $0.16 per gallon for non-DIY generators. This scenario also removes the $0.02 per gallon re-refining incentive. Sensitivity analysis was performed to determine the effect of price elasticity assumptions.
Testing Requirement[9]	Evaluate the impacts of the testing requirements for out-of-state transportation of used oil. Very little data were available for this scenario, and therefore the analysis relied mostly on anecdotal evidence obtained from discussions with stakeholders and used oil transporters.

[9] Scenarios 9 and 10 were created to address PRC section 48651.5(b)(1)(C). The testing requirement also is included in this PRC provision.

Scenario 1
This policy scenario investigated the likely effects of increasing the Do-It-Yourself (DIY) incentive payment from its current level of $0.40 per gallon to $0.80 per gallon.

The direct impacts model determined that this would result in a relatively small (1.6 million gallons per year) increase in used oil collected, with a corresponding decrease in uncollected oil. The additional collected oil is expected to be used for recycled fuel oil, mostly out of state.

A sensitivity analysis was performed to determine the effect of the price elasticity assumption (the relationship between dollars and response). The standard assumption is reported here; however, when the assumption was reduced to one-tenth of the original value, the changes from the baseline were reduced to nearly imperceptible levels.

The LCA model reported very small, almost negligible, benefits (approximately 2 percent) as a result of this change.

The cost benefits analysis reported somewhat significant cost ($4.9 million), and the addition of an insignificant number of jobs, based on modeling capabilities.

Based on the entirety of the results, this scenario shows very minor environmental benefits at a somewhat significant additional cost.

Scenario 2
This policy scenario is very similar to Scenario 1, except that the additional $0.40 per gallon incentive is given to non-DIY generators such as auto repair stations, quick lube shops, and rental vehicle companies. This would increase the current incentive for this group of generators from $0.16 to $0.56 per gallon.

The direct impacts model determined that this would result in a moderate increase in the collection of used lubricating oil (12.1 million gallons per year) and a corresponding decrease in uncollected oil. The additional collected oil is expected to be used for recycled fuel oil.

A sensitivity analysis was performed to determine the effect of the price elasticity assumption (the relationship between dollars and response). The standard assumption is reported here; however, when the assumption was reduced to one-tenth of the original value, the changes from the baseline were reduced to nearly imperceptible levels.

The LCA model reported a moderate decrease in environmental impacts (12 percent to 27 percent change from the baseline) in all environmental impact categories except for criteria air pollutants, which had an increased impact of 13 percent from the baseline. The increase in impacts to the criteria air pollutants category is due mainly to the fact that the additional oil collected would be combusted as recycled fuel oil, which produces significant amounts of particulate matter.

The cost benefits analysis reported a small cost savings ($1.2 million) with the addition of a significant number of jobs to the economy (701).

Based on the entirety of the results, this scenario shows the possibility of moderately significant environmental benefits across all categories except for criteria air pollutants and the addition of a significant number of jobs and a small economic benefit as well. It is important to note that any scenario

that increases the amount of used oil combusted as a fuel will result in greater impacts to the criteria air pollutant category. The only scenarios that show a decrease in this category are those in which re-refining activity is shown to increase. These benefits are only realized if the underlying price elasticity assumption is correct. If the alternative assumption is closer to accurate, these benefits will not be realized.

Scenario 3
This policy scenario is very similar to Scenario 1, except that the additional $0.40 per gallon incentive is given to generators of industrial oil (such as machine shops, metal working facilities, and other industrial users). Industrial oil generators currently do not receive any incentive payment.

The direct impacts model determined that this would result in a moderate increase in the collection of used industrial oil (9.1 million gallons per year) and a corresponding decrease in uncollected oil. The additional collected oil is expected to be used for recycled fuel oil.

A sensitivity analysis was performed to determine the effect of the price elasticity assumption. The standard assumption is reported here; however, when the assumption was reduced to one-tenth of the original value, the changes from the baseline were reduced to nearly imperceptible levels.

The LCA model reported a moderate decrease in environmental impacts (a 9 percent to 20 percent change from the baseline) in all environmental impact categories except for criteria air pollutants, which experienced an increased impact of 10 percent from the baseline. The increase in impacts to the criteria air pollutants category is due mainly to the fact that the additional oil collected would be combusted as RFO, which produces significant amounts of particulate matter.

The cost benefits analysis reported a very small cost ($1.3 million) with the addition of a significant number of jobs to the economy (791).

Based on the entirety of the results, this scenario shows the possibility of moderately significant environmental benefits across all categories except for criteria air pollutants and the addition of a significant number of jobs while remaining nearly cost-neutral. It is important to note that any scenario that increases the amount of used oil combusted as a fuel will result in greater impacts to the criteria air pollutant category. The only scenarios that show a decrease in this category are those in which re-refining activity is shown to increase. These benefits are only realized if the underlying price elasticity assumption is correct. If the alternative assumption is closer to accurate, then these benefits will not be realized.

Scenario 4
This policy scenario investigated the likely effects of increasing the market value for used oil by $0.40 across all categories and for all generators but did not specify a mechanism for achieving this. This would increase the current average market value for used oil in California from $0.30 to $0.70 per gallon.

The direct impacts model determined that this would result in an increase of lubricating oil collection of 12.1 million gallons as well as an increase in industrial oil collection of 9.1 million gallons, with a corresponding decrease in uncollected oil. The additional collected oil is expected to be used for recycled fuel oil.

The LCA model reported a somewhat significant decrease in environmental impacts (a 20 percent to 47 percent change from the baseline) in all environmental impact categories except for criteria air pollutants, which experienced an increased impact of 23 percent from the baseline. The increase in impacts to the

criteria air pollutants category is due mainly to the assumption that the additional oil collected would be combusted as RFO, which produces significant amounts of particulate matter.

The cost benefits analysis reported a somewhat significant cost savings ($9.8 million) and the addition of 540 jobs.

Based on the entirety of the results, this scenario shows the possibility of somewhat significant environmental benefits across all categories except for criteria air pollutants and the addition of a significant number of jobs while also providing a reasonable cost savings. It is important to note that any scenario that increases the amount of used oil combusted as a fuel will result in greater impacts to the criteria air pollutant category. The only scenarios that show a decrease in this category are those in which re-refining activity is shown to increase. These benefits are only realized if the underlying price elasticity assumption is correct. If the alternative assumption is closer to accurate, then these benefits will not be realized.

Scenario 5
This scenario investigated the likely effects of increasing the difference between the fee paid for virgin lubricating oil and the fee paid for re-refined lubricating oil by reducing the fee paid for re-refined lubricating oil by $0.10 per gallon from the current value of $0.12 per gallon to $0.02 per gallon.

The direct impacts model determined that this would not result in the collection of any additional used oil but would divert a very small amount of used oil (1.2 million gallons per year) currently being used for recycled fuel oil to use as re-refined lubricants.

The LCA model reported a nearly imperceptible change across all impact categories; however, a small decrease (8 percent) in impact to the criteria air pollutants category are expected due to a reduction in combusting used oil as a fuel in preference of re-refining into base lubricants.

The cost benefits analysis reported a somewhat small cost ($3.1 million) and a very small number of job losses (28). The net costs to the system are experienced mostly by the State of California in the form of reduced fee revenues.

Based on the entirety of the results, this scenario shows the possibility of very small environmental benefits at a similarly small net cost.

Scenario 6
This scenario is similar to Scenario 5; however, the incentive for re-refining is provided to the re-refiners of used oil directly rather than toward the purchase of finished lubricating oil made from re-refined base lubricants by increasing the current $0.02 per gallon incentive by $0.10 per gallon.

The direct impacts model determined that this would not result in the collection of any additional used oil but would divert a very small amount of used oil (900,000 gallons per year) currently being used for recycled fuel oil into use as re-refined lubricants.

The LCA model reported a nearly imperceptible change across all impact categories; however, a small decrease (7 percent) in impacts in the criteria air pollutants category are expected due to a reduction in combusting used oil as a fuel in preference of re-refining into base lubricants.

The cost benefits analysis reported a somewhat small cost ($2.7 million) and is jobs-neutral. The net costs to the system are experienced mostly by the State of California in the form of increased incentive payments.

Based on the entirety of the results, this scenario shows the possibility of very small environmental benefits at a similarly small net cost.

Scenario 7
This scenario investigated the likely effects of providing a new incentive for the production of distilled fuel from used oil (MDO) in the amount of $0.10 per gallon. There is currently no incentive for this product.

The direct impacts model determined that this would not result in the collection of any additional used oil but would divert a very small amount (0.4 million gallons per year) of used oil currently being used for recycled fuel oil into use as a distilled fuel.

The LCA model reported a nearly imperceptible change across all impact categories.

The cost benefits analysis reported a somewhat small cost ($2.9 million) and is jobs-neutral. The net costs to the system are experienced mostly by the State of California in the form of increased incentive payments.

Scenario 8
This scenario investigated the likely effects of providing a new incentive for the production of recycled fuel oil from used oil in the amount of $0.10 per gallon. There is currently no incentive for this product.

This scenario did not result in any changes in any of the models as the recycled fuel oil market is assumed to receive all used oil collected that is not demanded by either re-refiners or distilled fuel (MDO) producers. RFO is the lowest-cost product that is produced from used oil and therefore does not compete economically with the other disposition routes.

Results of Statutorily Required Scenarios—PRC Section 48651.5(b)(1)(C)

Senate Bill 546 made significant changes to the California Oil Recycling Enhancement Act. A portion of the act required CalRecycle to:

> *(C) Evaluate the positive and negative impacts of the testing requirements established in Section 25250.29 of the Health and Safety Code, the tiered fee on lubricating oil established in Section 48650, and the tiered incentive payments established in Section 48652, on used oil collection rates.*

In an effort to address the provision and assess the impacts of both the tiered fee structure and the tiered incentive structure (including the re-refining incentive), CalRecycle and its contractors created two scenarios and analyzed them similarly to the other eight hypothetical policy scenarios. These are presented below as Scenario 9 and Scenario 10. These scenarios used the models to determine the impacts associated with returning the fees and incentives back to their values before SB 546; for this reason, the

results from the contractors' reports must be inverted (i.e., signs must be reversed from positive to negative and vice versa) in order to determine the impacts of the original change.

The testing requirement established in HSC section 25250.29 was not well-suited to a direct impact assessment using the economic models and the LCA model. In order to determine this impact, two pieces of information were analyzed: how much used oil left California both before and after the testing requirements was implemented, and whether there was any change in the type or composition of the oil that left California. The results of this analysis are presented below as "Testing Requirement Impacts."

Scenario 9

This scenario was created to estimate the effects of the tiered fee structure that was created by SB 546. The changes were made in an effort to incentivize the production of re-refined lubricating oil by creating a fee differential between lubricating oils produced from virgin lubricants and those produced from re-refined base lubricants. This was accomplished by increasing the fee for virgin lubricating oil from $0.16 per gallon to $0.24 per gallon and decreasing the fee for re-refined lubricating oils from $0.16 per gallon to $0.12 per gallon. The recent implementation of this new fee structure has provided too little empirical data to determine its impacts directly. As such, the economic models were used to determine the likely effect if the fees were returned to their original values. The results of this analysis can then be used to estimate the expected impacts of the tiered fee structure.

The direct impact model determined that the most likely result of the tiered fee structure would be the diversion of a small amount of used oil (1.1 million gallons) currently being used for recycled fuel oil to use as re-refined base lubricants.

The lifecycle assessment reported nearly imperceptible changes to environmental impacts across all categories, except for a small decrease (9 percent) in criteria air pollutant impacts.

The cost benefit analysis reported a very small cost savings ($400,000) and a small number of jobs lost (48).

Based on the entirety of the results, this scenario shows the possibility of very small environmental changes at a similarly small net cost. This suggests that the new tiered fee structure implemented by SB 546 does not result in a significant increase in re-refining.

Scenario 10

This scenario was created to estimate the effects of the tiered incentive structure that was created by SB 546. The changes were made in an effort to encourage more DIY-generated oil to be collected by increasing the incentive payment from $0.16 per gallon to $0.40 per gallon, as well as to encourage additional re-refining of the used oil that is collected by providing an incentive to re-refiners in the amount of $0.02 per gallon. The re-refining incentive was effective as of Jan. 1, 2013 and as of the date of this report CalRecycle has not received any claims, meaning no empirical data is available to determine its impacts directly. As such, the economic models were used to determine the likely effect if the incentives were returned to their original values. The results of this analysis can then be used to estimate the expected impacts of the tiered fee structure.

The direct impacts model determined that the most likely result of the tiered incentive structure would be a small increase (1 million gallons per year) in used lubricating oil collected (100,000 gallons of that from DIY generators) and a nearly imperceptible increase (100,000 gallons per year) in re-refining activity.

The lifecycle assessment reported a nearly imperceptible change in environmental impacts across all categories.

The cost benefits analysis reported small changes to net costs ($300,000) and to jobs created (66).

Based on the entirety of the results, this scenario shows virtually no change from the baseline condition. This suggests that the tiered incentive structure implemented by SB 546 does not increase collection of used oil or increase re-refining.

Testing Requirement Impacts

The requirement to have used oil tested prior to transporting the oil out of state was intended to prevent environmental problems from being shipped out of state for other states (with lower environmental protection requirements) to deal with. California does not want to ignore the impacts of material generated within its borders, regardless of where the environmental impacts occur.

In order to determine whether this requirement has in fact reduced the amount of oil that is shipped out of state to avoid environmental regulations within California, three pieces of information were needed: 1) whether there was a change in the volume of used oil that moved across state lines after the implementation of this testing requirement; 2) whether oil was prevented from crossing state lines because it failed to pass the new testing criteria; and 3) whether processors altered the oil they attempted to ship out of state under the presumption that it would not meet the new testing criteria.

This requirement has not been in place long enough to make definitive statements regarding its efficacy, as most of the information gathered is anecdotal. Based on the information available to us at the time of this analysis, there appears to have been no change in the amount of used oil shipped out of California after the implementation of the new testing requirement. Further, anecdotal information has suggested that none of the oil tested has failed to meet the requirements for out-of-state transport. Lastly, anecdotal information suggests that used oil brokers have not altered their operations in order to avoid transporting used oil out of state that is not likely to pass the testing criteria.

Taken together, this preliminary and anecdotal data suggest that most of the oil being transported out of state prior to the testing requirement was already meeting the standards set in statute.

"Disposition" Scenario Results

"Disposition" scenarios, as they are referred to in this report (they are referred to as "extreme" scenarios in the lifecycle assessment contractor report), describe four scenarios in which all of the used oil that is generated in a given year is assumed to be routed though one of the four disposition routes available for used oil: re-refining, distillation and use as a light fuel (MDO), processing and use as a heavy fuel (recycled fuel oil, or RFO), and improper disposal. While these scenarios do not represent a condition that is either technically or economically feasible, they provide "endpoints" or "bounds" for the analysis by amplifying potential differences between the various disposition routes. This is particularly helpful due to the small differences seen in the results of the hypothetical policy scenario analyses. These scenarios were analyzed only by the LCA model for environmental impacts and were not analyzed by either of the economic models.

Two major findings can be drawn from the results of these analyses. First, improper disposal has greater environmental impacts across every impact category studied when compared to the baseline. Secondly, among the legal disposition routes, differences are relatively small and vary across the impact categories.

The impacts associated with the improper disposal of used oil are closely tied to a number of assumptions that were made in this study. Some of these assumptions are related directly to the amount and fate of the used oil that is improperly disposed, while others are related to the toxicity impact models used to determine various impacts associated with toxicity to the environment and human health. While perfect knowledge is not possible related to the fate of improperly disposed oil, informed assumptions have been made to most accurately approximate this volume. In contrast, toxicity impact models are inherently highly variable and generate difficulties with all lifecycle analyses (see additional detail in the "Limitations" section below). The results associated with this study are driven greatly by two emissions: zinc and non-methane volatile organic compounds. Unfortunately, the data available on the toxicity of these two emissions are not well known, and this generates a significant amount of uncertainty. Even with this uncertainty, CalRecycle is comfortable stating that the analysis shows that improperly disposing of used oil is worse for the environment than any disposition route chosen once the oil is collected.

The second major finding concerns relative impacts of additional three "disposition" scenario analyses. This issue is controversial and reflects analyses that are based on certain assumptions and that have inherent uncertainties. Part of the difficulty arises due to the multiple impact categories that are being investigated. Sometimes there are trade-offs, such as when a disposition route is more beneficial in three of the eight impact categories but has a greater impact in the other five categories. Because the environmental impact categories span a wide range of impacts (greenhouse gases to human toxicity to environmental toxicity to smog formation), it is difficult to determine which group of impacts is better or worse than the others. Making such a determination would entail value judgments that are not in the purview of a lifecycle analysis.

Based on a thorough analysis of the results as well as in-depth consultation with the contractors (who are familiar with the inherent error and uncertainty) and the stakeholder group, the following summarizes the relevant information:

- All three disposition routes generate net reductions in global warming potential, acidification potential, and smog creation potential. This means that the avoided burdens in these categories are greater than the accrued burdens from processing and using the material.
- Processing and use of used oil as a heavy fuel (RFO) generates net impacts across the five remaining impact categories: ecotoxicity potential, eutrophication potential, and the three human health impact categories of cancer potential, non-cancer potential, and criteria air pollutants.
- Re-refining used oil into new base lubricant generates net reductions in eutrophication potential, ecotoxicity potential, human health non-cancer potential, and human health cancer potential. This means that re-refining generated net benefits in all studied impact categories except for human health (cancer). While impacts from re-refining did generate greater impacts to human health (cancer), it should be noted that the actual impact is very small: The LCA estimates that re-refining all of the used oil generated in California for a year generates an estimated total of 0.275 cancer cases.
- Distilling used oil into light fuels (MDO) generates net reductions in eutrophication potential and human health cancer potential. This means that distillation into light fuels generated net benefits in all studied impact categories except for human health cancer potential, human health non-

cancer potential, and ecotoxicity. While impacts from distillation did generate greater impacts to human health (non-cancer), it should be noted that the actual impact is very small: The LCA estimates that distilling all of the used oil generated in California for a year generates an estimated total of 0.595 non-cancer cases.

- Re-refining generates the largest net reductions in global warming potential, eutrophication potential, ecotoxicity potential, human health non-cancer potential, and human health cancer potential. Again, it is noteworthy that the values for the human health impact categories are very low.
- Processing and use of used oil as a heavy fuel (RFO) generates the largest net reductions in acidification potential. Although both RFO and MDO can be expected to have the same sulfur content, only RFO is burned in facilities with potentially high sulfur retention.

Based on its review of this information, CalRecycle concludes that there is no single "best" disposition route among the three formal options of re-refining, distillation (MDO), and use as a heavy fuel (RFO). There are some differences in impact categories among the various options; some of those differences are extremely small while others are somewhat larger but still relatively small. Even those differences that begin to approach significance only do so when amplified in this kind of analysis; such differences would be very difficult to determine when viewed within the current technological and economic constraints and end-uses that exist in the used oil market in California. However, if one examines a single gallon of oil and attempts to determine the most environmentally beneficial way to process that gallon of oil, all other things being equal (meaning it is not contaminated or otherwise technically incapable of being processed by all of the disposition routes), then re-refining and distillation into a light fuel (MDO) are nearly equal in terms of environmental impact and use as a heavy fuel (RFO) is somewhat more environmentally impactful.

LCA Critical Review Results

As part of the International Organization for Standardization (ISO) requirements for completing a lifecycle assessment to be used for policy making purposes, a critical review was completed by a team of unbiased, qualified reviewers as described in the LCA Critical Review section. CalRecycle contracted with six entities, including a review chair and five review panel members, to work together to accomplish this task. Following is a summary of the critical review team's conclusions provided by the panel chairperson. The full report can be found on CalRecycle's website.[10]

> *The critical review of the University of California, Santa Barbara (UCSB) LCA of used oil management in California, as documented in the final Contractor Report dated July 29, 2013, concludes that the LCA team did a thorough and well documented LCA given the available database of emission and discharge stream composition data and the available data on the quantities of used oil directed to the several management options employed in practice. Moreover, the final Contractor Report represents a distinct improvement over the advance draft report issued in March 2013. The LCA performed adopted accepted protocol and procedures, and results were reported in accordance with ISO reporting standards. In light of the available input data for the LCA, many input parameters were based on assumed values. In these cases, sensitivity analyses were performed with the parameter varied over a range of possibilities, and resulting impacts on LCA results were reported.*

[10] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1468

Throughout the LCA, critical review panel comments on the progress of the LCA were readily considered and, for the most part, appropriately addressed by the LCA team. Resolution of many reviewer comments is reflected in the LCA final report.

The critical review process has helped assure that the study met the ISO 14040 standards. The scope and activities of the study were consistent with LCA standards and the UCSB team was aware of the requirements for peer reviewed LCAs. UCSB took great effort to perform technically valid data collection activities to enhance the understanding of used oil management, emissions from combustion processes, and the disposition routes for used oil. The UCSB team reviewed all available public information as well as proprietary data. The study used standard assessment models to examine the impacts of used oil processing. The scenarios for the study were developed in conjunction with an economic study of used oil recycling, which among its many objectives, aimed to relate used oil policies with collection rates and processing options. CalRecycle will be interpreting the results of the study in its report to the legislature; so, interpretation of the results by the study team was not within the scope of the study.

Several critical review comments and observations highlight potential areas for future research.

Regarding the sensitivity analyses, the thorough assessment of the toxicity sensitivity is definitely a welcomed addition to the final report. The testing of different LCA methods and the most sensitive parameters clearly shows all the possible range of variability for results and conclusions. However, the complexity and number of analyses presented in the report make it difficult for the reader to draw strong and useful conclusions. CalRecycle will need to discuss the variability of the emissions impacts of the oil management pathways in their interpretation of the study results.

Regarding the environmental impact assessment, it was suggested that UCSB ensure that the GaBi Envision model provided to CalRecycle be consistent with that employed in the final report. There are differences between the emissions data in the most recent GaBi Envision model provided to reviewers and the emissions data included in the final LCA report that appear to be substantial. Consistency between the model version employed for the final LCA report and that provided to CalRecycle is important. A more easily accessible version of the study modeling tools should be made available to stakeholders.

The report states the following for the virgin lube producers: "The current modeling approach assumes that an increase in re-refined lubricating oil recovered leads to a corresponding displacement in virgin lube sales in California. The displacement is considered a net loss for virgin producers and ignores the possibility of increased exports to other states or increased production of other petroleum products." This can be seen as a net loss for virgin producers, but it would represent a net profit for the system; the overall operations get cheaper. From a societal perspective that is a good trend. The results seem to be skewed by the way they are handled now by only taking a direct economic 'value' perspective and this choice seems to be an important driver when looking at the results. Providing an interpretation from a consumer perspective could be valuable.

Finally, the LCA does not address the local impacts of used oil management, which is typical for an LCA. The study does not mention potential environmental justice concerns due to the potential distribution of emissions from used oil management, which should definitely be addressed in the interpretation of the results. (For more discussion, see Appendix B).

Overall, the critical review finds the scope of the assessment to be sufficient to achieve the study goals described in the final LCA report and provides detailed modeling results for informing recommendations and policy decisions based on the life cycle assessment of used oil management practices in California. There is a tremendous amount of knowledge the LCA team has gained on the impacts from used oil collection.

Economic Peer Review Results

Although there is no international standard for performing economic analyses, peer reviews are very common in the field of economics, and such a review was undertaken for the economic portion of this project. The economic review was overseen by the chair of the Economics Department at California State University at Long Beach. The review was conducted in two phases: The first phase was performed on a late draft of the model construction and reports, while the second phase was performed on the final versions of the models and reports. The review of the late draft was to provide expert feedback regarding any potential issues that could be addressed prior to completing the final reports. The review of the final models and reports serves as expert opinion regarding the appropriate use of economic theory and techniques in analyzing the used oil system in California. Following is a summary of the review team's input provided by the economic review coordinator.

The reviews of the draft and final economic models and reports were based solely on the information contained in the reports. The reviewers were provided with a verbal description of the project that discussed the objectives of SB 546, an overview of the life-cycle analysis conducted by UCSB, and the structure of the contract for the economic model. The reviewers were then charged with the task of analyzing the implementation and structure of the economic models including the direct impacts model, the benefit-cost model and the application of REMI. Each reviewer provided their independent assessment focusing on one element of the modeling. The reports of the reviewers were provided as separate documents instead of one document integrating all the comments. A summary of the findings was provided at each stakeholder meeting and is posted as a PowerPoint with all the documentation on the portal maintained by California State University, Sacramento.

The overall comments on the economic models were positive with statements such as "the DIM is relatively straightforward to use" and "there are no fatal flaws." Reviewers did not express concerns about the underlying economics. However, there were some issues raised such as the limitations in the benefit-cost analysis on what could be quantified monetarily. One reviewer suggested that all the impacts should be discussed qualitatively since so few of the impacts could be reliably quantified. However, it is important to understand that the reviewer was evaluating the benefit-cost report in isolation from the rest of the project reports. When considered holistically, the changes in emissions and discharges for the various policy options for a wide variety of pollutants, such as water and soil impacts and heavy metals, are presented in LCA report.

Peer reviewers expressed concerns about the lack of reliable and comprehensive data from primary sources. Not all stakeholders were willing to share data even under the protection of a confidentiality agreement, and certain gaps remained in the data. CalRecycle and the LCA contractors frequently discussed the importance of quality data during the stakeholder meetings. The discussions include the types of data required, the level of detail needed for analyses, and also a discussion of how margins of error would be affected by poor data. Multiple stakeholders assured

CalRecycle that the information being requested was available from multiple sources, that they already had the information in their possession, and that it had been previously assembled and could be easily transmitted. CalRecycle and the LCA contractors repeatedly asked stakeholders to provide this data, but very little comprehensive data was actually provided.

Overall, the reports submitted by ICF International considered the comments from the first review panel and modified their reports for the final version where appropriate. As CalRecycle prepares the synthesis report that draws on the information from all three contractor reports as well as the findings of the review panels for the LCA and the economic models, a more complete picture of the linkages between the models will be apparent.

Policy and Research Options

Potential Policy Options

PRC section 48651.5 requires that this study: 1) determine the impacts on the collection rate attributed to the new tiered fee and incentive structure as well as the out-of-state testing requirements; and 2) provide any recommendations for statutory changes that may be necessary to promote increased collection and responsible management of used oil. The Results and Key Findings section above describes how different scenarios, including ones with varying incentives, affect collection rates. This section presents potential policy options that are supported by the analysis and that could result in increased collection and responsible management of used oil.

After careful review of the contractors' reports and input from the stakeholder group, CalRecycle identified 13 major policy options that are supported by the results of the analysis and that could result in increased collection and responsible management of used oil. CalRecycle presented these potential policy options to the stakeholder group for input at a workshop on Sept. 25, 2013. CalRecycle solicited verbal and written comments associated with the policy options presented in order to better inform its final analysis and recommendations to the Legislature. The potential policy options presented below incorporate many, but not all, of the comments and suggestions provided by the stakeholder group.

There is universal consensus among stakeholders that the primary goals of California's used oil management program are to increase the collection of used oil and reduce the environmental impacts associated with used oil management (including improper disposal). While great strides have been made in these two areas over the past 20 years, CalRecycle recognizes that the current fee and incentive structure may not be the most effective way to achieve program goals. It may be possible to restructure expenditures and incentives in the used oil fund toward actions that directly increase collection or reduce impacts.

TABLE 4: CALRECYCLE POLICY OPTIONS

Topic		Option	Statutory, Regulatory, Administrative
Target Incentives for Specific Activities	**1**	Direct payments for CCC activities	Statutory and Regulatory
	2	Augment local government funding and activities	Statutory and Regulatory
Reduce Generation of Used Oil	**3**	Reestablish "Check Your Number" campaign	Administrative
	4	High-efficiency oil filters	Administrative
	5	Encourage increased oil drain intervals, maintenance lights, sensors; partner with vehicle manufacturers	Statutory and Regulatory
	6	Service station oil change stickers	Statutory and Regulatory
Increase Market Value of Used Oil	**7**	Direct payments to used oil haulers	Statutory and Regulatory
	8	Remote oil collection incentive	Statutory and Regulatory
	9	Reimburse some regulatory expenses	Statutory and Regulatory
	10	Investigate disparate used oil market value	Administrative
Reduce Environmental Impact of Processing Used Oil	**11**	Create an incentive for distilled fuel production	Statutory and Regulatory
	12	Increase pollution control requirements for RFO	Statutory and Regulatory
Add Industrial Oil to Fee/Incentive System	**13**	Include industrial oil in the fee and incentive system	Statutory and Regulatory

The rest of this section presents and describes these 13 potential policy options (CalRecycle's actual recommendations regarding these policy options are provided in the following section).

Policy options 1 and 2 below describe two potential approaches to directing the incentive payments to certified collection centers and/or local jurisdictions for activities specifically designed to increase collection of used oil and reduce improper disposal. Potential policy options 3 through 6 are aimed at decreasing the generation of used oil leading to a decrease in the amount of improperly disposed used oil. Mechanisms 7 through 10 attempt to increase the market value of used oil by redirecting the current recycling incentive payments and/or reducing regulatory compliance costs. Potential policy options 11

and 12 attempt to reduce the environmental impacts from the processing of collected used oil. Finally, option 13 would bring industrial oil into the used oil program's fee and incentive structure.

Most of the options will require legislation to adjust the way the oil funds are allocated. Only options 3, 4, 5, and 10 could be accomplished administratively. Some of the options present additional implementation challenges such as ensuring that the incentive will actually result in the intended actions, and defining criteria for distributing incentives. These challenges, along with stakeholder positions when applicable, are described in each of the options listed below. Following this section, the Recommendations section includes a qualitative discussion of whether certain options may work better together.

Target Incentives for Specific Activities (Options 1 and 2)
As described in the direct impacts model[11] and the Economic Baseline Results section, the current financial incentives have not resulted in significant increases in used oil collection. It is difficult to know whether these incentives have impacted improper disposal. By redirecting existing incentives to specific activities, the goals of increased collection and responsible management could be achieved. Some possible adjustments include:

1. **Direct Payments for Certified Collection Center Activities**
   This option would entail making payments directly to the CCCs for active participation in the used oil program in lieu of the current per gallon incentive that is paid to CCCs. A tiered payment rate could be established based on total collection volumes, Do-It-Yourself collection volumes, location of the collection center (urban or rural), and specific activities conducted by the collection center (for example advertising, oil filter collection, etc.). Actual payment rates and eligible activities would be determined through further analysis of oil collection data and would reflect the level of participation that certified centers receive from the public. It is possible that such direct payments may attract additional businesses to participate as CCCs due to reduced administrative and documentation requirements.

   A tiered incentive could be structured to support CCCs operating in remote areas or those that collect large volumes of used oil from Do-It-Yourselfers (DIYers). These businesses often receive a much lower price for their used oil in the market and in some cases must pay to have their used oil managed appropriately. In addition, the effort required to file a claim may not be worth the incentive payment received. Since few used oil recycling opportunities exist in rural and remote areas, DIYers may have a difficult time finding a convenient recycling center and may tend to dispose of their used oil improperly more often than DIYers in urban settings. Supporting CCCs in remote areas and those that generate small volumes of used oil would directly target improper disposal. The cost to implement Option 1 is highly variable depending on the specific payment rates. Currently, there are about 3,300 certified collection centers in urban areas and about 400 in rural areas. Depending on the actual incentive, total costs for this option could range from $1.5 million to more than $6 million. (Note that Option 8 below describes an option that would also provide support to remote areas, but that option is structured to function within the context of the existing incentive system.)

[11] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1467

Option 1 would require statutory changes. Stakeholders are generally supportive of this concept, since they feel that the DIY incentive is not effective in encouraging behavior change and should be eliminated or redirected. *CalRecycle recommends this option.*

Implementation Challenges: Significant additional data is still needed regarding used oil generator behavior and motivation, along with location and ultimate disposition of uncollected oil. Effective implementation of this option would require a concerted multi-stakeholder effort to better understand generator behavior and determine the appropriate level of payments, including incentives for rural areas that will accomplish program goals. Specific criteria would have to be developed to define which entities would be eligible for the remote and small volume generators. GIS mapping could be used to easily identify criteria based on distance from registered used oil haulers. It is possible that this option could be implemented with existing funding; however, the resulting payments may not be sufficient to ensure active participation by collection centers and convenient collection opportunities for the public. Moving to a direct payment system will result in the loss of data currently obtained through incentive claims that are tied to the number of gallons of used oil collected at each collection site. This information can be valuable when local jurisdictions evaluate the success of regional programs.

2. **Increase Payments to Local Jurisdictions**

The existing local government Used Oil Payment Program could be augmented to ensure that local agencies undertake specific activities beyond their normal used oil programs. Eligible activities could include supporting local certified collection centers in addition to activities targeted to reduce improper disposal such as code enforcement efforts. Specific expenditures would be determined through further analysis of oil collection data and with input from local program managers. This option could be structured to redirect all of the existing collection incentives to local jurisdictions, or maintain a portion of the existing incentives and use the remainder to augment the Used Oil Payment Program.

This option would require statutory changes. Stakeholders are generally supportive of this concept, since they feel that the DIY incentive is not effective in encouraging behavior change and should be eliminated or redirected. (An alternative would be to maintain all of the existing economic incentives and increase the manufacturer's fee to cover the costs of Option 2. However, most stakeholders would not support an increase in the manufacturer's fee.) *CalRecycle does not recommend this option because Option 1 (direct payments to certified used oil collection centers) has a greater potential to affect significant changes in used oil collection.*

Implementation Challenges: Local programs vary considerably in their effectiveness. Some jurisdictions already conduct excellent used oil programs in their communities and do not require additional funding, while others would greatly benefit from funding and assistance in identifying and implementing program components. It would be challenging to determine which local jurisdictions should receive additional funding and to define exactly what activities would be eligible. As in Option 1, more information is needed regarding generator behavior and motivation to implement Option 2 effectively. Decision makers would have to decide if all or a portion of the current recycling incentives should be redirected to local government payments. In order to ensure that CCCs remain active participants in the program, it would likely be important to retain a portion of the incentive payments to CCCs.

Reduce Generation of Used Lubricating Oil (Options 3-6)
The environmental benefits resulting from increased used oil collection also can be achieved by reducing the amount of used oil that is generated in the first place. Source reduction is the pinnacle of the waste management hierarchy and should be a high priority in any strategy to reduce environmental impacts.

The following four options focus on reducing the amount of used oil that is generated in California. While a reduction in generation will reduce the volume of used oil that is improperly disposed, the LCA and economic analyses did not specifically model these policy options, and quantification of the impacts is uncertain. Even so, the "disposition scenario" for informal used oil management showed that the environmental impacts from improper disposal far outweigh the impacts from any of the formal management routes; therefore any strategy that reduces the amount of improperly disposed used oil will improve the responsible management of used oil.

While reducing the amount of used oil generated will have significant environmental benefits, it is difficult to know what portion of the reduced generation would have been collected and what portion would have been improperly disposed. To provide a rough estimate of this, CalRecycle used information from the economic analysis performed in the direct impacts model, specifically, that the current ratio of collected to uncollected oil is 82 percent to 18 percent.[12] If the assumption is made that this ratio will apply equally to the reduced generation, then a reduction in 10 million gallons of used oil generation would result in a reduction in improper disposal of approximately 1.8 million gallons. It is possible that far more or less than an 18 percent reduction in improperly disposed oil could result from a reduction in used oil generation.

A reduction in used lubricating oil generation could be achieved through Options 3 through 6. These source reduction options only pertain to lubricating oils and not to industrial oils, as it is unclear what factors could be used, if any, to reduce the generation of used industrial oil even though the environmental benefits from a reduction would likely be very similar.

3. **<u>Continue and Expand Statewide Outreach</u>**
   CalRecycle implemented an outreach campaign called "Check Your Number" to encourage consumers to use their vehicle's user manual to follow the manufacturer's recommended oil drain intervals (which are often much longer than 3,000 miles). This program was reliant on media campaigns to increase awareness and understanding, proved successful in its targeted markets, and points to the appeal of consumer outreach. This option would reestablish the campaign and expand into additional markets with direct consumer outreach, as well as develop materials for local jurisdictions to use and customize for their own purposes. As with the first iteration of this outreach campaign, this expanded version would leverage the appealing consumer message of vehicle owners benefiting economically from extending their oil change intervals.

   This option does not require legislation and enjoys universal stakeholder support. CalRecycle and its stakeholders are committed to the precept that consumer education and outreach – at both the state

[12] Note that the 82 percent number is from a particular year, whereas the 75 to 80 percent range provided earlier is meant to convey the general trend over a number of years.

and local levels – will continue to be an important element in achieving the state's oil management and recycling goals. Authorization to implement a broader campaign via an external contract would be necessary. *CalRecycle recommends this option.*

Implementation Challenges: As with any advertising or public outreach effort, it is difficult to quantify a cause-and-effect relationship between the campaign and consumer behavior. Interviews and surveys can provide insight into awareness and actions, but there are often multiple contributing factors to actual behavior change.

4. **Promote High-Efficiency Filters**

High-efficiency filters can extend the useful life of lubricating oils by filtering out impurities with far greater efficiency than standard filters. Initial investigation into the effectiveness of these filters began with a study completed in 2008 by DTSC under contract with CalRecycle (at the time, the California Integrated Waste Management Board) and will continue with further research beginning in fiscal year 2013/2014. This option would implement high-efficiency filter demonstration projects and roll out successful projects statewide. This option has the additional benefit of working with used oil generators beyond Do-It-Yourselfers. For example, large fleet operations can be targeted with pilot programs along with trade associations and vehicle manufacturers.

This option does not require statutory changes and enjoys broad stakeholder support. *CalRecycle recommends this option.*

Implementation Challenges: It may be difficult to secure commitments from fleet managers to use high-efficiency filters even if strong evidence is presented regarding their effectiveness.

5. **Increased Oil Drain Intervals, Maintenance Lights, Sensors**

Establishing a minimum standard for oil drain intervals on all new vehicles sold in California would decrease the amount of used oil generated. Oil drain intervals are determined by a combination of the design of the vehicle's engine and the formulation of the lubricating oil. Some effort has already been directed by vehicle manufacturers and oil formulators to increase drain intervals and decrease wear and emissions. Additional work is likely to result in even greater drain intervals, but is unlikely to occur without statutory requirements. Longer drain intervals could also be encouraged by requiring vehicle manufacturers to use new technology. New vehicles come with indicator lights that can be designed to notify the driver to change the oil after the recommended number of miles have been driven. (Some vehicles do this, but others recommend service much sooner.) Frequently, a vehicle's maintenance lights are used to notify the driver of any and all maintenance needed (including tire rotation) rather than just an oil change. This leads to confusion on the part of the driver resulting in the vehicle having its oil changed more often than recommended or needed. The option to design indicator lights could be further customized by the addition of oil quality sensors to new vehicles to provide more accurate oil change recommendations based on driving conditions and environmental conditions.

This option could be pursued on a voluntary basis, but is unlikely to be successful without statutory change. Because of the difficulty of imposing California requirements on the automotive industry, *CalRecycle does not recommend this option.*

Implementation Challenges: Since the regulation of automobile specification is done primarily at the federal level, California does not currently have the authority to impose state requirements for new vehicles above and beyond those imposed by the federal government. While California has a federal exemption that allows it to set stricter air pollution/emissions requirements, that exemption would not be applicable to mandatory minimum drain intervals or technology improvements. Without some type of legislative mandate, it would be very challenging to solicit industry's active participation in this effort. For these reasons, *CalRecycle does not recommend pursuing this option with either a voluntary or legislative approach.*

6. **Establish New Requirements for Service Station Stickers**

   Longer drain intervals could be encouraged by requiring appropriate customer noticing in service stations. Service stations typically provide their customers with a reminder decal or sticker to change their oil after 3,000 miles or by a specific date. Requirements could be established for service stations to recommend the next service based on the manufacturer's recommended oil change interval rather than the typical 3,000 miles driven. Service stations could implement this practice with relative ease as they typically have to access the manufacturer specifications for relevant information, such as oil/air filter size and could access the oil change interval information at the same time. Service stations also could be provided with the proper manufacturer recommended intervals at no cost through an expanded Check-Your-Number campaign (see Option 3).

   This option would require statutory change. *CalRecycle recommends this option.*

   Implementation Challenges: A new regulatory requirement might engender opposition from the automotive service industry. CalRecycle administrative costs could increase with new oversight and enforcement responsibilities. Enforcement activities could range from self-policing to regular random inspections, and would incur different levels of costs depending on the staff time required.

Increase Collection of Used Oil by Increasing the Market Value (Options 7-10)

Collecting more of the used oil that is generated in California is a key component of the used oil program. This study, along with others completed on this subject, has shown that used oil improperly disposed results in negative environmental impacts across all impact categories studied. This study has also shown that collection and processing used oil generates positive economic benefits to the used oil management industry. Based on the results of the analyses performed during the course of this project, CalRecycle believes that collecting more of the used oil currently being generated would result in both environmental and economic benefits for California regardless of how the oil is properly managed once it is collected.

There is broad consensus among stakeholders that to increase the collection of used oil and reduce the environmental impacts associated with used oil management (including improper disposal), it is necessary to increase the market value of used oil in California. Stakeholders frequently commented that the market price of used oil is generally higher in other parts of the country than it is in California (further discussion of this issue is provided elsewhere, including Option 1, and 10 below). Throughout this LCA project, stakeholders and CalRecycle and its contractors have had extensive discussions about the reasons for the disparate market value and ways these differences could be overcome. Many stakeholders have suggested that financial mechanisms could be introduced in an attempt to level the playing field of management costs between California and the rest of the country. During the workshop held in September 2013, stakeholders were generally supportive of the options discussed below.

Even with a broad consensus, it is important to acknowledge that the absolute magnitude of the differences in economic and environmental impacts between improperly disposed used oil and used oil that is properly managed is subject to a great deal of uncertainty. While the analysis performed during the course of this project utilized the best information available, certain assumptions were necessary and may have had an effect on some of the results. While a higher market value for used oil will result in a higher collection rate, the exact quantitative relationship between the market value for used oil and collection rates is subject to uncertainty, and so an increase in the value for used oil may not produce the degree of additional used oil collection that was modeled during this analysis. In some parts of the state, the value of used oil is currently very low or may actually have a negative value (cost). It is likely these areas would experience the greatest increase in collection rates as a result of a change in used oil market value.

An increase in the market value (or perceived market value) could potentially be achieved through the following mechanisms:

7. **Direct Payments to Used Oil Haulers**

   Paying haulers an incentive of $0.40 per gallon for each gallon of used oil collected from generators could increase the market value of used oil by an equal amount (the market value for used oil is the value that a generator such as a service station or auto parts store can expect to be paid for used oil). This hauler incentive would be in addition to the current incentives paid to used oil generators.

   Used oil haulers travel throughout the state to pick up used oil from generators. Where large quantities of used oil are generated and businesses operate in urban areas, haulers are able to pay a high price to the generator for their used oil. However, in order to be profitable, when picking up oil from very small generators or in remote locations the hauler pays a lower rate or may even charge the generator to manage their used oil. By offering an incentive to the used oil hauler, a base market value would be assured, regardless of location or quantity. This assumes that the used oil hauler would then pass on some or all of that incentive payment to its customers (i.e., the used oil generators).

   CalRecycle and its contractors attempted to model the effects of increasing the market value of used oil by $0.40 per gallon (see Hypothetical Policy Scenario 4). This analysis estimated that increasing the market value of used oil by this amount would result in increased used oil collection of 20 million gallons per year, create roughly 540 new jobs, and result in a 20 percent to 50 percent decrease in environmental impacts across most categories. Other potential changes to the market values were not modeled but could be modeled in the future to determine impacts of various hauler incentives. The relationship between change in market value and collection is linear, so alternative values can be easily extrapolated.

   This option would require statutory change and a funding source. Option 7 cannot be implemented without Option 13, which provides a new funding source. Option 13 below (adding industrial oil to the fee and incentive system) would be subject to the requirements of Proposition 26 (2010). *CalRecycle recommends this option.*

   Implementation Challenges: Making direct payments to used oil haulers will only increase the value of used oil if it is passed on throughout the used oil market. There is no way to ensure that this will happen unless regulations are passed requiring the haulers to pass the payment (or a specific portion of the payment) on to the generator. The success of this option will depend on the competitive market

place both within California and in comparison with other states. Since used oil is often hauled through multiple transfer stations before it arrives at a processor, an effort must be made to ensure that the hauler incentive is paid only once on the same volume of oil. This could be accommodated by creating a generator certification process, which will entail more administrative costs. If an incentive is created at the $0.40 per gallon rate as modeled in Scenario 4, the estimated cost of the incentive would be $32 million, which would require a new revenue source to be fully funded; whether a lower payment rate would be more effective in achieving optimal results is not known.

In addition, to be effective, this incentive payment must apply to both lubricating and industrial oils, because once used oil is collected it is consolidated and can no longer be identified as either lubricating or industrial oil. As a result, industrial oils would need to be included in the fee structure, subject to Proposition 26 (2010), in order to ensure that both types of oils are being treated equally, as well as to provide a funding source for this type of incentive.

8. **Remote Oil Collection Incentive**

Paying an incentive to generators or transporters for used oil that is collected in remote or otherwise difficult-to-reach areas could counteract the reduced market value for used oil in those areas. This would be in addition to the existing incentives paid to used oil generators. This option is similar to Option 1 above (i.e., eliminating existing generator incentives and instead providing direct payments to certified used oil collection centers). However, in contrast to providing a tiered incentive to all CCCs (with a higher amount going to remote centers), Option 8 would provide the incentive solely to haulers or generators in remote locations or to those that generate small quantities of used oil. This is because generators of used oil that operate in urban areas or manage large quantities of used oil are currently receiving the best market prices for their used oil. Those operating in rural areas or who manage small quantities often are offered much lower prices for their used oil and in some circumstances are required to pay a significant amount to have their used oil managed. The oil generated at the latter type of facility is most at risk of being improperly managed.

Targeting an incentive at those generators could be more likely to result in increased oil collection. A rural incentive set at four times the current incentives ($1.60 per gallon for Do-It-Yourself oil and $0.64 per gallon of non-Do-It-Yourself oil) would cost about $1.1 million to implement and could be accommodated by current oil program revenues if implemented on its own.

This option would require statutory change. *CalRecycle recommends Option 1 above rather than Option 8 as a more effective mechanism to achieve program goals.*

Implementation Challenges: Specific criteria would have to be developed to define which entities would be eligible for the incentive payment. GIS mapping could be used to easily identify criteria based on distance from registered used oil haulers.

9. **Reimburse Some Regulatory Compliance Costs**

Making direct payments to those that handle used oil to cover some of their regulatory compliance costs could help level the playing field for California businesses. Regulatory compliance costs of concern stem from DTSC's regulatory oversight of hazardous waste generators. Some of the costs specifically associated with the used oil hauling industry include hazardous waste handling fees and compliance costs. Additionally, regulations currently limit the volume and length of time that used oil can be stored, creating additional expenses for small-volume generators. Doing business in California can, in some cases, be more expensive than in other states. Some of these costs apply to all businesses

in California while others are specific to the used oil industry. These additional costs can result in used oil haulers offering lower prices to used oil generators, which may negatively impact collection rates. Since an increase in expenses is likely to result in a decrease in the market value for used oil, it is reasonable to assume that a reduction in costs would result in an increase in the market value of used oil. CalRecycle could reimburse some of these costs for used oil haulers in an effort to reduce the operating costs and increase the market value for used oil.

The option would require statutory change. *CalRecycle does not recommend this option because it does not consider it appropriate for a State agency to reimburse regulatory compliance costs for California businesses.*

Implementation Challenges: This option would require close coordination with DTSC to ensure that appropriate hazardous waste management standards are maintained and that such reimbursements do not create an incentive for lesser compliance. Staff notes that DTSC regulatory fees are incurred on both lubricating and industrial oils, while the Used Oil Fee is only charged on lubricating oils. The cost of this policy would depend on the reimbursement amount. For example, an $800 per site reimbursement would cost $2.2 million to implement and could be accommodated by current oil program revenues if implemented on its own; however, a $5,000 per site reimbursement would cost $13.4 million and would require a new revenue source to be fully funded.

10. **Investigate Disparate Market Value of Used Oil**
    Stakeholders assert that the price paid for used oil in California is less than in other states. Continued economic research to determine the cause of the disparate market value for used oil in California will help focus efforts in a more informed manner. This information could be useful in specifically focusing on adjusting the exact market forces that are causing this condition.

    This option would not require statutory changes but would require a funding source. *CalRecycle does not recommend this option because the limited available data is not likely to provide sufficient information to assist with policy recommendations in the future.*

    Implementation Challenges: The data required for this type of analysis are extremely difficult to obtain. Most of the information is highly confidential concerning price, costs, market share, and other financial data. For this lifecycle assessment and economic analysis, contractors repeatedly sought information from potential data providers and were unable to obtain substantial information in spite of nondisclosure agreements. While monies could be diverted from other contracts for this effort, it is questionable whether spending additional resources on this research would yield valuable results.

Reduce the Environmental Impact from Processing Used Oil (Options 11-12)
Once used oil is collected and enters the used oil management system, there are currently three main options for how that used oil is managed and processed: recycled fuel oil production, distillation into a distillate fuel (marine distillate oil), or re-refining into a base oil. A portion of this study was aimed at determining whether environmental and/or economic benefits could be realized if one or more of those options were encouraged in preference to the other(s). There is some evidence that environmental benefits could be achieved if less used oil were processed into and used as refined fuel oil. In particular, the combustion of RFO in the extreme scenario generated somewhat significantly higher environmental impacts in the areas of eutrophication, ecotoxicity, human health (non-cancer), and criteria air pollutants (see the “Disposition” Scenario Results section). This suggests that if some portion of the used oil currently being processed into and used for RFO were to instead be processed into and used as a distilled

fuel or as re-refined lubricating oils, some environmental benefits could be realized in most environmental indicator categories included in this study.

However, as discussed elsewhere (see LCA Baseline Results and Appendix A: Interpretation Issues), the models responsible for determining the impacts of RFO combustion rely on a number of assumptions that are uncertain to varying degrees because data was out of date or unavailable. This may result in the differences between the environmental impacts associated with RFO and those associated with re-refining and distillation as reported by the lifecycle assessment model being overstated or understated. Also, the use of used oil as RFO often displaces dirtier fuels, resulting in net environmental benefits in the categories of global warming and acidification.

It may be possible to divert some used oil from RFO use through the following mechanisms:

11. **Create an Incentive for Distilled Fuel Production**
    The lifecycle analysis showed there is very little difference in the environmental impact categories from the production of distilled fuel and re-refined oil, which suggests these could be incentivized similarly. At the same time, the economic analysis determined it is currently highly unlikely for additional used oil to flow into the re-refining pathway. Re-refineries pay a premium for their used oil feedstock to ensure access to the highest-quality used oil and ensure their facilities are running at full capacity, and as a result there is little unused capacity. This currently leaves used oil distillation as the most likely route to accept additional used oil if some were to be diverted away from RFO production and use. (However, it is noteworthy that at the time of this report, the only used oil re-refiner in California had been recently acquired by a large company that owns and operates other large-scale used oil re-refineries out of state. This may alter market dynamics and lead to expansion of in-state re-refining capacity, which would allow both the distillation pathway and re-refining pathway to accept additional oil that is currently diverted from RFO production and use.)

    Creating an incentive to drive more collected used oil away from the RFO pathway and into the MDO pathway is likely to cost an additional $1 million to $1.5 million annually. This additional expense could be accommodated with current used oil program revenues. (An alternative to incentivizing the production of distillate fuels would be to eliminate the existing incentive for re-refined base lube production.)

    This option would require statutory change. *CalRecycle recommends this option.*

    Implementation Challenges: This option engenders significant disagreement between stakeholders. Some stakeholder believe that the findings in the LCA show a sufficient difference between the impacts of RFO combustion and the production of either distilled fuel or re-refined base lube to justify continuing the current incentive for re-refined lube oil production and establishing an equal incentive for distilled fuel production. Other stakeholders feel equally strongly that the uncertainty of the data, particularly the combustion data for RFO, do not support giving preference to one management process over any other. CalRecycle would need to determine the proper incentive and how to apply this incentive to ensure equitable treatment due to differences in yield rates between the two processing routes. The current requirements established in SB 546 for re-refiners to qualify for the additional incentive ($0.02 per gallon) have proven to be very challenging to implement due to the burdens of verifying certain aspects of the re-refining process. These requirements include, for example, verifying that all oil being processed is lubricating oil generated in California. Some stakeholder comments suggested that, if incentives are to be provided, restrictions that dictate eligible

expenses be imposed on recipients of these incentives. This would require extensive regulations and administrative oversight and enforcement to implement.

12. **Increase Pollution Control Mechanisms for RFO Combustion**
    New requirements for pollution control mechanisms in the combustion of RFO could reduce emissions of pollutants. In this way, similar environmental benefits could be had without incentivizing any particular disposition route over another.

    This would require statutory change. *CalRecycle does not recommend this option because insufficient information currently exists and implementation would require changes to federal laws and regulations.*

    Implementation Challenges: Much of the used oil that is processed into RFO is combusted outside of California and would therefore not be subject to emission control requirements imposed by California. Even within California, regulatory requirements for emissions are not under the purview of CalRecycle and would have to be undertaken by the California Air Resources Board and/or regional air quality management districts. It might be possible, however, to condition the payment of the current generator incentive on the requirement that end users comply with pollution control mechanisms required by California and federal statutes and regulations.

Include Industrial Oil in the Fee and Incentive Program (Option 13)

The California Oil Recycling Enhancement Act established a system of fees and incentives to encourage the collection and proper management of used lubricating oil and develop alternatives to the illegal disposal of used oil. Industrial oils are not included in the system, yet present the same management challenges as lubricating oil. Industrial oils are defined in statute as "any compressor, turbine or bearing oil, hydraulic oil, metal-working oil, or refrigeration oil" (Public Resources Code 48616).

13. **Include Industrial Oil in the Fee and Incentive System**
    Since one of the primary purposes of the CORE Act is to prevent the illegal disposal of used oil, all oil should be included in the management system. Adding a fee on the sale of industrial oil sold in California would provide an equitable regulatory system for lubricating and industrial oil, and increase the revenue in the used oil fund, thereby making additional monies available for purposes related to collection and recycling. This option would be subject to the requirements of Proposition 26 (2010). The lack of a fee on industrial oils makes tracking sales and collection of this oil difficult; data from the direct impacts model[13] has shown that up to 50 percent of the initial industrial oil sales volumes reported to CalRecycle are subsequently exported from California, without such exports being reported to CalRecycle. While an estimated 75 to 80 percent of available lubricating oil is collected annually, based on the LCA research only about 55 percent of available industrial oil is collected statewide. The inclusion of industrial oils in the fee and incentive system would therefore allow CalRecycle to focus its attention on a portion of the waste stream that has a much lower recovery rate and provide valuable data to help CalRecycle target efforts to increase the collection of industrial oil. CalRecycle staff estimates that an additional $17 million would be generated annually if the industrial oil fee and incentive were the same as the current lubricating oil fee rates.

[13] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1467

This option would require statutory change. *CalRecycle recommends this option.*

Implementation Challenges: Statutory changes would be necessary to change the definitions of "industrial oil" and "industrial generator" as well as to incorporate industrial oil into the fee and incentive system. Certain industrial oils are meant to be consumed in use and should be exempted from the fee and incentive system. As industrial oil sales are estimated to be 60 million to 80 million gallons per year, additional staff would likely be needed to implement the new fee and incentive payment program. This option would be subject to the requirements of Proposition 26 (2010).

Potential Research Options

While a significant amount of new knowledge was gained during the course of this study, additional research would provide greater clarity and understanding related to the management of used oil. Because much of such research falls within the scope of CalRecycle's mission, some has already been planned and funding sources identified, as described below. Other areas of research discussed below are of a highly specialized nature; while CalRecycle could direct research on these; such research would likely only be successful if CalRecycle were given sufficient authority to obtain relevant data.

Research Currently Planned or in Progress

CalRecycle has already anticipated the need for a number of research concepts that have also been identified in the used oil LCA project. These are planned as projects under CalRecycle's Three-Year Used Oil Spending Plan (most recently approved in September 2013) and include the following:

Creating a tool to allow for future adjustments and manipulation of the results of this LCA: CalRecycle understands that many of the environmental and economic inputs to the LCA may change in the future, whether due to the discovery of new data, updates and revisions to existing data, or changes in technology. A tool will be built that will allow the LCA model to incorporate such adjustments to assess environmental impacts of future situations. This tool could also be used to analyze hypothetical changes to the used oil management system and provide guidance for future policy decisions. The tool will be accessible by the public.

Researching high-efficiency oil filters: An interagency agreement with DTSC was executed in FY 2012/13 to research options and develop protocols for the use of cart-type high-efficiency filters and oil sensors in large fleets as well as oil testing to determine remaining useful life. The final results of this agreement can be used to implement programs for large fleets in FY 2013/14, and provide filter carts, sensors and oil testing services through contracts.

Curbside oil research: An interagency agreement or a contract with a private entity will perform research to identify barriers to curbside oil collection programs and how to overcome them. This contract will also survey the characteristics of jurisdictions that have successful curbside programs and use this information to identify other jurisdictions which would be well-suited to curbside collection and assist in the creation of targeted local programs.

Additional Research Recommendations

CalRecycle has also identified other areas that could benefit from additional research but has not yet determined the most appropriate manner to address them. While sufficient funding currently exists for these projects, CalRecycle does not believe they are likely be successful without additional authority to

require data or other assistance from specific entities. This conclusion is based on the difficulties CalRecycle and its contractors experienced during this project in obtaining primary confidential information (see Appendix A: Interpretation Issues, and the Used Oil Market discussion above).

Uncollected oil research: Previous CalRecycle studies on uncollected oil focused on identifying Do-It-Yourself (DIY) populations throughout the state were based on surveys conducted in 2001 and are now out -of -date. This project will update the current status of DIY populations statewide, and will also attempt to identify non-DIY generators such as agriculture, small businesses, and marinas that may not currently properly dispose of their used oil. The project will determine how much uncollected oil is available for collection and what the current fate of that oil is. The second part of the project will focus on behavioral/motivational research in order to determine how best to influence the generators of that oil to manage it properly.

Increasing knowledge of industrial oils: This project will utilize an Interagency Agreement or a contract with a private entity to perform research to determine ways to increase recovery of industrial oils, utilizing information learned in the LCA. Industrial oil generators will be identified throughout the state, and then their usage of industrial oils will be assessed to determine how it can be modified to encourage source reduction and/or minimize oil loss. The findings of the project will then be implemented in the following year through another contract.

Providing increased collection opportunities and convenience: Currently, there are segments of the population that lack convenient access to collection opportunities. This contract will fund the development of designs for a fully functioning compact facility to accept used oil and some forms of universal waste from the public. The design should include full costs for equipment as well as approvals from DTSC, Certified Unified Program Agencies, and the fire marshal, and an engineer's stamp. The final plans will be made available to local jurisdictions. Funds will then be provided for local jurisdictions to construct small used oil collection facilities based on the designs. CalRecycle would prioritize funding facilities built in areas more than 5 miles from another certified collection center and provide secondary priority to areas with CCCs located 3 to 5 miles from one another.

Reestablish the "Check Your Number" campaign: Manufacturers' recommended oil change intervals have been updated so the "Check Your Number" website database remains current. However, the marketing effort behind the campaign ended in December 2012 with the expiration of a $1.2 million outreach contract. To assist existing outreach activities being conducted by local jurisdictions, a new application is in development by CalRecycle that can be used by mobile devices, such as iPads or Android tablets, to access the "Check Your Number" database without the need for an active Internet connection. This will allow local jurisdiction representatives to show members of their communities the manufacturers' recommended oil change intervals for their vehicles while out at mobile education events where Internet connections may not be available. To further the reach of the campaign and build on its initial success would require reestablishment of the public education effort (see Option 3 among CalRecycle's recommendations), with additional funding directed toward specific radio markets to improve public awareness and familiarity with the "Check Your Number" campaign, website, and resources, using the radio ads previously developed under the campaign.

Enhanced combustion model: An enhanced combustion model would provide a more accurate assessment of the environmental impacts of the different processes that utilize fuel derived from used oil. This would require significant participation from the users of these fuels, not only to develop an understanding of the variety of fuels used, but to also understand the variety of pollution control methods and environments in

which the fuel is burned. Multiple stakeholders informed CalRecycle that this data is readily available and indicated that it would be provided during the course of the LCA associated with this report. However, despite repeated requests for the information, the detailed data required for a robust lifecycle assessment was not provided. Based on this, CalRecycle concludes that it would likely be necessary for the Legislature to require this type of participation in order for CalRecycle or a contractor to be successful in obtaining relevant information. Even with such authority, it still may be difficult to obtain data because many of the entities using these fuels are located out of state. CalRecycle believes the used oil fund could provide sufficient funds for the development of this model.

Enhanced primary refinery model: An enhanced model would provide a more accurate assessment of environmental impacts from primary refining processes. This would require significant participation from primary petroleum refiners providing data and process information. Multiple stakeholders informed CalRecycle that this data is readily available and indicated that it would be provided during the course of the LCA associated with this report. However, the necessary information was not provided during the used oil LCA despite multiple requests to all stakeholders. It would likely be necessary for the Legislature to require this type of information disclosure. CalRecycle staff believes the used oil fund could provide sufficient funds for the development of this model.

Toxicity/emissions study: CalRecycle recognizes that the toxicity models used in the study could be improved with further research. CalRecycle could coordinate with the Office of Environmental Health Hazard Assessment and the California Department of Fish and Wildlife's Office of Spill Prevention and Response to develop a new model to more accurately determine the toxicity impacts associated with various environmental emissions. The accuracy of the toxicity models was a specific item of concern for many stakeholders; however, they were unable to provide any alternative, more accurate models to be used for the LCA. OEHHA currently receives a direct appropriation from the Used Oil Recycling Fund, which could be used to fund this research.

Enhanced Used Oil Market Model: Additional economic modeling of the used oil market in California could provide information to help focus efforts on increasing used oil collection. Many stakeholders assert that that the price paid for used oil in California is less than it is in other states. Further research could attempt to determine the cause of the disparate market value and identify potential options to adjust specific market forces that are causing this condition. Additional research could also be conducted to better understand price elasticity in relation to used oil collection, as well as other factors affecting price determination in the used oil market. CalRecycle does not recommend this research because it would require significant participation from all used oil stakeholders, as the data required for this type of analysis are extremely difficult to obtain. Most of the information concerning price, costs, market share, and other financial data is highly confidential. The Legislature would need to require stakeholder participation in order for CalRecycle to be able to receive sufficient data to complete this research. However, since much of the necessary information would have to come from participants in the used oil management system operating outside of the state, even legislative requirements would not address all of the data needs. In addition, CalRecycle would have to coordinate closely with DTSC. Many stakeholders have stated that the costs of complying with the hazardous waste management standards overseen by DTSC is a significant contributor to the lower value of used oil in California.

CalRecycle Policy Recommendations

SB 546 charged CalRecycle with conducting a comprehensive lifecycle analysis and making recommendations for statutory changes that may be necessary to promote increased collection and responsible management of used oil.

Based on the entirety of the environmental lifecycle assessment, economic analyses, and extensive stakeholder interaction, CalRecycle recommends a suite of seven options—Options 1, 3, 4, 6, 7, 11, and 13—that could work together to achieve the legislative goals of promoting increased collection and responsible management of used oil. These options focus on decreasing the generation of used oil, increasing collection of used oil that is generated, decreasing the impacts associated with processing used oil, and creating equity where inequity currently exists.

Five of these options would require legislation to adjust the way oil funds are allocated, and all have associated implementation issues that would need to be addressed. Only Options 3 and 4 could be accomplished administratively. In order to fully implement this suite of options, additional revenue is needed in the used oil fund. Option 13 recommends including industrial oil in the used oil fee and incentive system and would be subject to the requirements of Proposition 26 (2010). The rationale for these recommendations is discussed below. While other combinations of potential policy options could be implemented, CalRecycle views this suite of options as the most effective way to increase the collection and proper management of used oil in California. CalRecycle does not recommend any changes to the testing and reporting requirements established by SB 546.

The recommendations presented below can be implemented in a variety of ways by adjusting the manufacturer's fee amount, the various payment amounts, the hauler incentive amount, and the amounts used for competitive grants and the Check Your Number campaign. For example, if the manufacturer fee were kept at its current level ($0.24 per gallon for virgin lubricating oil, $0.12 per gallon for re-refined oil, no fee on industrial oil), then the hauler incentive (Option 7) could not be implemented, direct payments to certified collection centers (Option 1) would be minimal, and competitive grants might have to be eliminated. On the other hand, if the manufacturer fee were increased slightly (for example by $0.06 per gallon for a fee of $0.30 per gallon), and an equal fee were added on the sales of industrial oil, the hauler incentive could be implemented, direct payments to certified collection centers would likely be adequate to achieve program goals, and competitive grants could be maintained. Numerous other combinations could be explored; these examples are meant to provide general guidance only. Significant additional analysis will be required to determine the true fiscal impacts of any potential statutory change.

Option 1 (direct payments for CCC activities) would remove the current per-gallon incentives provided to collection centers and Do-It-Yourself oil generators as this incentive has not been shown to be effective in driving additional used oil collection. In order to maintain participation in the Certified Collection Center system and ensure convenient collection opportunities for the public, centers would receive an annual payment based on their activity. Higher payments would be offered to CCCs in remote areas in order to offset some of the additional collection costs incurred there.

Options 3 and 4 (Reestablish "Check Your Number" campaign and promote high-efficiency oil filters, respectively) can be completed under existing statutory authority. These source reduction options have full support of the stakeholder group and are efficient ways of reducing the impacts of used oil management by eliminating the generation of used oil at its source. Reestablishment of the Check Your

Number campaign (Option 3) has the potential to further decrease the amount of used oil generated by educating consumers regarding the recommended oil change interval for their vehicle (which is often much longer than 3,000 miles). While no additional statutory or regulatory authority is needed to implement this option, authorization to implement a broader campaign using an external contractor would be necessary. Option 4 would continue useful research into the implementation of high-efficiency filters and on-board sensors that could extend the useful life of lubricating oils beyond the manufacturer's recommended drain interval. High-efficiency filter demonstration projects would also be conducted.

Option 6 (service station, oil change reminder stickers) would require that service stations that change customer oil indicate the next recommended oil change service based on the manufacturer's recommended drain interval for their particular vehicle. This option would require statutory action to implement but would not require funding or have any financial impact on state funds.

Option 7 (direct payments to used oil haulers) would provide an additional incentive to used oil haulers to increase the value of used oil, which in turn could result in increased collection of used oil. The success of this option would depend on the competitive market place both within California and in comparison with other states. It would only increase the market value of used oil if the incentive were passed on throughout the used oil market. This is by far the most expensive policy option and would require an additional funding source. Option 13 (including industrial oil in the used oil fee and incentive system) would provide the necessary funding source and would be subject to the requirements of Proposition 26 (2010).

Option 11 (incentive for distilled fuel production) would remove the disparity currently in place between the production of re-refined base lube and distilled fuels made from used oil. The environmental analysis shows that the difference between the environmental impacts of these two processing options is not significant enough to justify an inequitable application of incentives.

Option 13 (inclusion of industrial oil) would include industrial oils in the existing fee structure. Used industrial oils must be managed as hazardous waste; they are treated and processed in the same manner as lubricating oils and are in fact often mixed prior to processing. Excluding industrial oils from the fee and incentive/payment system for used oil creates confusion, additional work, and lack of full understanding. These two broad categories of oils are not distinguished from one another by the oil industry or by DTSC and should not be distinguished by CalRecycle. Inclusion of industrial oils into the used oil fee and incentive structure would create equity, provide valuable data, and generate needed revenues to support other recommendations made here, particularly Option 7. Implementation of this option would be subject to the requirements of Proposition 26 (2010).

CalRecycle is not recommending Options 2, 5, 8, 9, 10, and 12. These options were developed and examined because they are supported by the results of the analysis and have the potential to advance the program goals of increased collection and responsible management of used oil. However, they are not being recommended at this time for various reasons outlined below. In general, CalRecycle views the recommended options as being more feasible and effective at achieving program goals within the limits of CalRecycle's authority. Option 2 (augment local government funding and activities) is not recommended because Option 1 (direct payments to certified used oil collection centers) has a greater potential to affect significant changes in used oil collection. Many local jurisdictions cannot accommodate additional funding for used oil projects due to budgetary restraints that restrict personnel from managing additional funding levels. Option 5 is not recommended because California does not have the authority to impose requirements on automobile manufacturers beyond federal requirements. It is unlikely that this option

would be successful if it were implemented on a voluntary basis. Option 8 (remote area collection incentive) is not recommended because it would be redundant of Option 1, which is recommended. (Option 1 would shift from a per-gallon incentive to a payment-for service-model that includes a tiered payment structure for rural collection centers.) Option 9 (reimburse some regulatory expenses) is not recommended at this time because CalRecycle does not consider it appropriate for a State agency to reimburse regulatory compliance costs for California businesses. Option 10 (investigate disparate used oil market value) is not recommended because CalRecycle does not expect that it would result in obtaining further information that would inform policy recommendations in the future. Option 12 (increase pollution control requirements for RFO) is not recommended because insufficient information exists to implement this option in an informed manner and because this would require changes to federal laws and regulations. Pursuing research on an advanced combustion model (which is recommended as part of the "Research" section above) to augment the existing used oil LCA would be necessary to determine the most effective way to implement Option 12.

Appendix A: Interpretation Issues

Understanding the Numbers

In order to interpret the results of the various analyses, readers should be aware of and understand three major considerations. First, in order to account for missing or insufficient data, a number of assumptions were necessary. Second, even existing data exhibit uncertainty, which also necessitates a number of assumptions. Third, given these two issues, the results of the analyses, while represented as discrete single numbers, are subject to certain unquantifiable error bands.

When conducting any lifecycle assessment, data is nearly always the limiting factor, and this LCA was no exception. To accurately catalog the environmental and economic impacts of every stage and every entity in the lifecycle of used oil management requires a very large amount of data. Despite extraordinary efforts by the contractors, some of the critical data needed for this study were unavailable or available in insufficient quantities. Therefore, in order to allow for a complete analysis, certain assumptions needed to be made to bridge the gap between the data needed and the data available. The extent of limitations and data gaps in this study are normal relative to such research.

Examples of the kinds of assumptions made include:

- the average number of miles driven by a used oil collection vehicle per gallon of used oil collected;
- the retention rates of certain heavy metals during combustion;
- the fuels that displace recycled fuel oil when combusted; and
- the amount of uncollected oil that is combusted on-site for heat.

When these assumptions are made and incorporated into the analyses, further sensitivity analyses were performed to determine how sensitive the results of the study as a whole are to these varying assumptions. The results of these sensitivity analyses can be found in the contractor reports (for example, see LCA final report,[14] pages 126–134).

Uncertainty exists even in high-quality data sets. When data from multiple sources are used in an LCA like this one, the uncertainty associated with each of the individual data sources is transferred and compounded into the final analysis. In most cases the uncertainty is either extremely small, unquantifiable, or both. Even so, these very small uncertainties (though at times larger) can add up to more significant uncertainty in the end results of the LCA. Due to the unquantifiable nature of these uncertainties, a qualitative assessment is needed along with some general guidelines in interpreting results. The final contractor reports identify the areas where large amounts of uncertainty exist and specify how additional work in the future may be able to reduce that uncertainty. The reports also describe how the uncertainty has affected the results of this study. For the areas of less uncertainty, some general guidelines can be used to simplify the interpretation of the results and to account for the compounded small uncertainties. This general guideline suggests that, when comparing the results of two or more sets of LCA results, differences of less than an order of magnitude are likely insignificant. However, this is not an area of formal consensus among LCA practitioners and certainly not among the stakeholders involved in this project.

[14] http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=1465

Because of the manner in which the various models were constructed (and to simplify the reporting of results), single numbers were generated as results in most cases. For example, this includes a single number of jobs created, or a single number of dollars in costs/savings, or a single number of carbon dioxide equivalents released to the atmosphere. It is important to keep in mind that although these numbers represent the best approximation given the data available and the modeling methodology used, there are unseen error bands associated with all of the results.

As has been previously mentioned, these uncertainties and errors are unquantifiable but exist nonetheless. When reviewing the results, it is important to keep this in mind, particularly when comparing results with small differences as these differences may in fact be indistinguishable from one another when the unseen error bands are considered.

Limitations of the Study

While it is widely acknowledged by both stakeholders and the peer reviewers that this study went far beyond the scope of other lifecycle assessments, it is not a perfect study, and a number of limitations exist that must be taken into account when reviewing the results. Several of the most significant limitations are described below. In addition, the contractor reports describe specific limitations and assumptions in their models and analyses.

Comparison of results: The results of this project range from costs associated with various entities within the used oil system to impacts on greenhouse gas emissions to polluting our waterways to job loss or creation. It is difficult to compare various scenarios due to these diverse impacts as well as the fact that oftentimes the various impact categories move in different directions. This results in multiple tradeoffs that need to be considered when making new policy decisions.

Combustion modeling: Additional work is needed to better understand the fuels portion of the used oil market. A great deal of effort was expended to obtain the highest quality data possible; unfortunately, high-quality data was unavailable to CalRecycle and its contractors. In the absence of this data, CalRecycle utilized the best data available and, based on input from the stakeholder group, its contractors created a combustion model for this project. The combustion model relies on a number of data sets that are old, incomplete, or both, and therefore relies heavily on assumptions (e.g., regarding the amount of zinc in used oil and its impacts, and retention rates). Due to the lack of available data, the contractors were not able to model the impacts of recycled fuel oil production under various pollution control mechanisms. Further primary research could be conducted by a qualified combustion engineer to develop a new combustion model, but the confidential process and market data (i.e. variety and composition of fuels used, pollution control methods, and environments in which the fuel is burned) would be difficult to obtain.

A further complication related to the combustion model is associated with fuel displacement (i.e., which primary fuels would be used if used oil-derived fuels were unavailable). Very little information was available on this subject, which required the contractors to rely heavily on assumptions based on single-source anecdotal information. Stakeholders were particularly critical of the assumption that natural gas is a displaced fuel and the assumption regarding the percentage allocated to each of the assumed displaced fuels. While many members of the stakeholder group indicated that the assumptions were incorrect or insufficient, acceptable alternatives were not provided. After speaking with members of the stakeholder group as well as other industry experts, CalRecycle and its contractors determined that the displacement

assumptions used in the final report were the most accurate available. Absent reliable data, equal allocation of fuel disposition is the only acceptable method of avoiding bias.

Lastly, displacement credits (i.e., the environmental burden avoided by not having to combust a primary fuel) are dependent on information regarding the production, composition and combustion emissions from those primary fuels. Primary fuel producers were unwilling to provide detailed information regarding their production processes (see Primary Petroleum Refining, below), nor were they willing to provide samples of their products for testing.

Confidential data: This analysis required information that was highly sensitive, and many companies and stakeholders were willing to share it with the contractors only under the condition that confidentiality of those data be maintained. For example, much of the process-specific and facility-specific information as well as price structure data used in this analysis were identified as confidential. Significant effort was taken to develop Non-Disclosure Agreements between the contractors and data providers. However, not all stakeholders were willing to share data even under the protection of a confidentiality agreement, and certain gaps remained in the data. Many areas of the study could be greatly improved with the addition of this information, were it made available. As a result, certain parts of the analysis are either non-transparent, averaged, or both.

Lack of reliable and comprehensive data: CalRecycle and the LCA contractors discussed the importance of quality primary data for a robust model and assessment to stakeholders in all of the stakeholders' meetings. The discussions include the types of data required and the level of detail needed for analyses, and also a discussion of how margins of error would be affected by poor data. Multiple stakeholders assured CalRecycle that the information being requested was available from multiple sources, that they already had the information in their possession, and that it had been previously assembled and could be easily transmitted. CalRecycle and the LCA contractors repeatedly asked stakeholders over the course of the entire LCA process to provide this data, but very little comprehensive data was actually provided, despite assurances that it would remain confidential. CalRecycle has received many criticisms of this study based on the quality of the data used, and while members of the stakeholder group have indicated that they possess higher-quality data, these data were not provided to CalRecycle or its contractors.

Benefits transfer limitations: Values for environmental emissions are highly controversial and very few values exist that have had the review and scrutiny necessary for this project. The U.S. Environmental Protection Agency and the National Academy of Sciences have accepted values for five categories, all of which are emissions to the air. No such reviewed and scrutinized values exist for emissions to land or water. More study in this area is certainly needed, but at the time of this study, severe limitations remain. The numbers provided for the benefits transfer portion of the economic analysis are subject to a high degree of uncertainty and require interpretation. For this reason, the numbers presented in the Hypothetical Policy Scenario section do not include the monetized benefits.

Limitations of toxicity impact assessments: Because toxicity impacts are of prime importance to this study, it was desirable to include toxicity impact characterization despite its high uncertainty. Every reasonable effort was made to include key toxic emissions in a consistent way across inventory data sources. This study uses the TRACI 2.0 lifecycle impact assessment methodology, which adopts the USEtox toxicity model. USEtox was developed out of the need to address the above-described uncertainties. Though USEtox is a consensus model and makes great progress in reducing fundamental uncertainties in toxicity impact assessment, it is still itself highly uncertain.

Primary petroleum refining: The process inventory model for primary refining used in the study was developed under contract specifically for this project by PE International, a consulting firm specializing in lifecycle assessment. The underlying refinery model contains proprietary information and therefore is available in a limited capacity for review. As constructed, this model was unable to utilize specific information from primary petroleum refiners, who considered it to be sensitive business information and were not comfortable providing it to the contractors, even under the protections of non-disclosure agreements.

Unknown fate of uncollected oil: An undetermined fraction of used oil meets an unknown fate, and therefore this study relies heavily on assumptions. While a great deal of effort was exerted in an attempt to enhance our knowledge of this material flow, much is still left to uncertain assumptions. Analyses were performed on a range of assumptions to provide a more complete picture of expected results.

Price elasticity: Price elasticity is an economic term that explains the responsiveness of an entity (a consumer or used oil generator, for example) to a change in price. Some stakeholders criticized the assumptions used in economic analyses, specifically the direct impacts model, for being inadequate to model consumer behavior in the used oil market. While the DIM attempted to model behavioral forces based on past studies and stakeholder input, these impacts would be better addressed by experts in behavioral sciences. In this study, the price elasticity was adjusted to a low value to take into account the observations made by local government staff as well as operators of certified collection centers regarding DIY behavior; specifically that most DIYers do not request the recycling incentive payment. The price elasticity value was then tested at a much lower value through a sensitivity analysis to better understand how different values would affect the results. Additional work could be undertaken to refine price elasticity assumptions, but considerable data from multiple sources would be required.

Environmental Justice: Lifecycle assessments do not typically have the ability to regionalize their impacts, and a regional analysis was not conducted in this LCA. The results of the LCA cannot differentiate based on where the impacts were emitted. A regional kind of analysis is more commonly referred to as a risk assessment. A risk assessment is often performed by environmental toxicologists and for a system as large as this one, would require a prohibitive amount of data that was not collected during the course of this LCA study. Such an assessment would a very difficult process for a system as large as the used oil management system in California. Further, access to sensitive financial data would be necessary; such data were impossible to obtain during the course of this study due to business concerns about confidential business information.

On an overall statewide basis, the policies proposed in this report will decrease negative environmental impacts. There are two major facilities in California responsible for processing California-generated used oil, one of which is located in an identified disadvantaged community. There are also a number of facilities located outside of California that accept and process California-generated used oil. Very large environmental impacts will be reduced by collecting and processing used oil as opposed to it being improperly disposed. However, processing this used oil might have its own, smaller, environmental impacts that will be centralized around the facilities that process the used oil. Depending on changes in the specific distribution of used oil flows to various processing facilities that occur as a result of new policies, this could result in somewhat increased impacts around those facilities.

Appendix B: Project Participants and Acknowledgments

List of Contractors

Lifecycle Assessment Practitioner – University of California, Santa Barbara; Roland Geyer P.I., Brandon Kuczenski, Ashley Henderson, Trevor Zink

Economic Study Contractor – ICF International; Paul Bailey, Richard Nevin, Bansari Saha, John Tortorella, Seth Greenburg

Economic Expert Subcontractor – Wade Martin, California State University, Long Beach

Critical Review Contractor, Panel Chair – Lifecycle Associates, LLC; Stefan Unnasch, Larry Waterland

Critical Review Panel Members: Ecoshift (Dustin Mulvaney); The Loreti Group (Chris Loreti); Quantis International (Francois Charron-Doucet); SCS Global Services (Keith Killpack, Gerard Mansell); Sound Resource Management (Jeffrey Morris)

Expert Facilitator – California State University Sacramento; Lindle Hatton, Gladys Glaude

Lubricant Consumption and Used Oil Generation Contractor – Kline and Company, Inc.; Ian Moncrieff

Primary Refining Data – PE International

Refinery Operational Data Contract – Solomon Associates; Jamie Brunk

Used Oil Laboratory Testing – Summit Environmental Technologies

Arizona State University – Mikhail Chester, Andrew Fraser

Project Team

- Contract Manager – Robert Carlson, CalRecycle
- Executive Sponsor – Howard Levenson, PhD, CalRecycle
- Team Members – Shirley Willd-Wagner, Emily Wang, CalRecycle
- DTSC Representative – Bob Boughton

List of Stakeholders

Attended Used Oil LCA Meetings		
First Name	**Last Name**	**Organization**
Dennis	Bachelder	American Petroleum Institute

Paul	Bailey	ICF International
Christie	Bautista	Department of Toxic Substances Control
John	Beath	Environmental Resources Management
Ed	Benelli	Department of Toxic Substances Control
John	Benton	World Oil Corp.
Bob	Boughton	Department of Toxic Substances Control
Ron	Brazell	Universal Lubricants, LLC
Lori	Brown	Earth911
Kevin	Buchan	Western States Petroleum Association
Teresa	Bui	Californians Against Waste
Russ	Burbank	Evergreen Oil, Inc.
Carlos	Chavez	HWMA
James	Chen	City Of San Diego
Gary	Colbert	Raibon & Colbert Associates, Inc.
Rachel	Cotroneo	Caltrans
Phil	Davies	BP
Steve	Dell'Anno	Lubrizol
John	Denholm	Oil Changer, Inc.
Ashley	Devierno	ENVIRON
Jennifer	Diciano	WRCOG
James	Douglas	Heartland Group Holdings, LLC
Denise	Duncan	Mattos & Associates
Patrick	Dyke	PD Consulting
Mike	Ebert	Safety-Kleen Systems, Inc.
Sara	Everitt	Chevron
Bryan	Fabian	Clearwater Environmental Management, Inc.
Andrew	Fraser	Arizona State University
Alejandro	Galdamez	Department of Toxic Substances Control
Federico	Garcia	ICF International

Edward	Genovese	Universal Lubricants
Dr. Thomas	Gloria	Industrial Ecology Consultants
Gretchen	Greene	Environ
Lisa	Grice	Environ
Darwin	Hall	Evergreen Oil, Inc.
Daniel	Halling	A-Line E.D.S. Inc.
Steve	Hamilton	California Polytechnic State University, San Luis Obispo
Brian	Haney	Thermo Fluids Inc.
Don	Harnack	Bango Oil
Howard	Hayes	Concawe
Brian	Heney	Thermo Fluids
Garrett	Jansma	World Oil Corp./Latham & Watkins, LLP
Dick	Jones	Department of Toxic Substances Control
Matthew	Kastantin	37Degree Filters, Inc.
Cynthia	Knowles	San Francisco Department of Environment
Christopher	Koffler	PE International Inc.
Richard	Leach	Exxonmobil
Cheryl	Lester	City Of San Diego, Environmental Services Department
Yong	Li	Caterpillar Inc.
Everette	Longshore	Safety-Kleen Systems, Inc.
Joanna	Louie	Department of Toxic Substances Control
Adam	Love	Johnson Wright, Inc.
Sharon	Loving	Fresno County Public Works & Planning, Resources Division
Christine	Mairabel	World Oil Corp.
Mike	Maloney	Universal Lubricants, LLC
Mike	Maloney Sr.	Universal Lubricants, LLC
Natalie	Marcanio	Department of Toxic Substances Control
Rand	Martin	Rose & Kindel
Deborah	Mattos	Mattos & Associates

Catherine	McCord	Heritage-Crystal Clean, LLC
Terry	McGann	California Strategies and Advocacy, LLC
Thad	McNeil	Evergreen Oil, Inc.
James	Mertes	Construction Resources Management, Inc.
Christine	Mirabel	World Oil Corp.
Jeffrey	Morris	Sound Resource Management Group
John	Muegge	Department of Toxic Substances Control
Carolyn	Nobel	Environ
Suzanne	Noble	Western States Petroleum Association
Theresa	Overton	Chevron
Scott	Parker	Nora, an Association of Responsible Recyclers
Mark	Phariss	Safety-Kleen Systems, Inc.
Dan	Pippard	Newalta Corporation
Alain	Portelance	Newalta Corporation
Billy	Puk	Recology San Francisco
David	Ramsden	Enviro-Lex Ltd
Charles (Charlie)	Rau	Exxonmobil Lubricants & Specialties Company
Mark	Rockel	Environ International Corporation
John	Rosenbaum	Chevron Base Oils
Mark	Saperstein	BP Lubricants, North America
Roy	Schumacher	Thermo Fluids Inc.
Prentiss	Searles	American Petroleum Institute
Jeff	Sickenger	KP Public Affairs for WSPA and API
Ted	Sinclair	Thermo Fluids, Inc.
Paul	Singarella	World Oil Corp.
Erica	Snedegar	Heartland Refinery Group, LLC
David	Sunding	World Oil Corp.
Terry	Thiele	The Lubrizol Corporation
Susanne	Trebert Haeberlin	Shell

Phil	Vermeulen	Independent Waste Oil Collectors and Transporters
Jack	Waggener, PE	URS Corporation
Niklas	Witte	School of Applied Sciences, Cranfield University
Alfred	Wong	Department of Toxic Substances Control
Xiaoying	Zhou	Department of Toxic Substances Control

Appendix C: Abbreviations and Acronyms

MDO – Marine Distillate Fuel
RFO – Recycled Fuel Oil
LCA – Lifecycle Assessment
DIM – Direct Impacts Model
CBA – Cost Benefit Model
CORE – California Oil Recycling Enhancement Act
DTSC – California Department of Toxic Substances Control
CCC – Certified Collection Center
UCSB – University of California at Santa Barbara
DIY – Do-It-Yourself Oil Changer