

UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF COLUMBIA

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NATURAL RESOURCES DEFENSE	)		
COUNCIL, INC.,	)		
	)		
Plaintiff	)	Civil Action No. 08-1363 (RJL)	
	)		
-v.-	)		
	)		
UNITED STATES DEPARTMENT OF	)		
STATE, et al.,	)		
	)		
Defendants	)		
	)		
TRANSCANADA KEYSTONE	)		
PIPELINE, LP,	)		
	)		
Defendant-Intervenor	)		
_____		)	

**[CORRECTED] DECLARATION OF GREG KARRAS**

I, Greg Karras, declare and say:

1. I reside in San Francisco and am employed as a Senior Scientist for Communities for a Better Environment (“CBE”). My duties for CBE include technical research, analysis, and review of information regarding industrial investigation, pollution prevention engineering, pollutant releases into the environment, and potential effects of environmental pollutant accumulation and exposure.

**Qualifications**

2. My qualifications for this opinion include extensive experience, knowledge, and expertise gained from two decades of industrial and environmental health investigation in the energy manufacturing sector, on toxic chemicals, and on petroleum refining in particular.

3. Among other assignments, I served as an expert for CBE and other non-profit groups in efforts to prevent pollution from refineries, to investigate alternatives to fossil fuel energy, and improve environmental monitoring of dioxins and mercury. I serve as an expert for CBE in collaboration with the City and County of San Francisco and local groups in efforts to replace electric power plant technology with reliable, least-impact alternatives. I serve as an expert for CBE and other groups in a project involving comprehensive investigation of environmental impacts of and alternatives to refining heavier, more contaminated oil in the San Francisco Bay Area.

4. I authored a technical paper on the first publicly verified pollution prevention audit of a California petroleum refinery in 1989 and the first comprehensive analysis of refinery selenium discharge trends in 1994. I authored an alternative energy blueprint, published in 2001, that served as a basis for the Electricity Resource Plan adopted by the City and County of San Francisco in 2002. From 1992 through 1994 I authored a series of technical analyses and reports that supported the successful achievement of cost-effective pollution prevention measures at 110 industrial facilities in Santa Clara County, California. I authored the first comprehensive, peer-reviewed dioxin pollution prevention inventory for the San Francisco Bay, which was published by the American Chemical Society and Oxford University Press in 2001. In 2005 and 2007 I co-authored two technical reports that documented air quality impacts from flaring by San Francisco Bay Area refineries, and identified feasible measures to prevent these impacts. My curriculum vitae and list of publications are appended hereto as Attachment 1.

## **Opinions**

5. I was asked for my opinions on whether existing information supports an assessment of potential impacts from greenhouse gases and flare emissions attributable to the refining of oil to be delivered by the Keystone pipeline. A list of documents I reviewed for this task is appended hereto as Attachment 2. My opinions are as follows:

6. It is possible to conduct a preliminary assessment of the Keystone pipeline's potential impacts on both greenhouse gas emissions and flaring pollution at U.S. refineries. These pollution impacts can be estimated from publicly available information on (1) the volume of crude oil to be delivered by the pipeline; (2) the source and disposition of that oil, (3) its composition and refining characteristics, (4) the processing conditions necessary to refine it into gasoline and other finished products, and (5) the types and amounts of pollutant releases generated by these processing conditions.

7. Although precise estimates are difficult without more information, my preliminary assessment confirms that the greenhouse gas and flaring impacts of refining the oil to be supplied to U.S. refineries by the Keystone pipeline would be substantial. For example, some very preliminary calculations indicate that had the U.S. State Department ("State Department") conducted analysis of greenhouse gas impacts from a few key refining sources alone, it could have found that processing the oil Keystone is projected to deliver to U.S. refineries could generate roughly 1.5 million to 5.4 million metric tons per year of incremental greenhouse gas emissions.

8. More precise estimates of the greenhouse gas and flaring impacts from refining Keystone oil could be developed with additional information that should be readily available to the State Department through public sources or information requests to

Keystone. This information would include more complete data for: (a) the quality and refining characteristics of the oils refined now and those to be delivered by the pipeline, (b) oil specifications in delivery contracts, (c) process and flare system designs of the refineries planning to process this oil, (d) the energy requirements of those refining processes, and (e) the mix of fuels to be burned for energy by those processes.

9. The basis for these opinions is set forth in this declaration, and can be summarized as follows:

- The Final Environmental Impact Statement (“FEIS”) and other documents identify the oil to be delivered by the pipeline, areas where it would be produced and refined, a range of amounts to be delivered, and three refineries planning to process it. This oil is more precisely characterized as a group of oils that is called Western Canadian Heavy (“WCH”) crude oil herein.
- Measurements used to predict the refining characteristics of crude oils show that, relative to the current refinery input in the delivery area and to most oils worldwide, WCH has an abundance of sulfur and metals, and of hydrocarbons that are larger than those which make up gasoline, diesel or jet fuels.
- These characteristics predict that efficiently making transportation fuels from WCH instead of the lighter, less contaminated oil mix refined in the pipeline delivery area will require the expansion of a set of refining processes that have large energy and hydrogen requirements. Demand for hydrogen that is fed to refinery processes, in particular, would increase substantially and require much larger energy inputs to make this additional hydrogen.

- Observations of refineries that currently process WCH in significant amounts are consistent with these predictions from the refining characteristics of WCH. Planned and recently built equipment expansions at refineries planning to process Keystone pipeline oil also are consistent with these predictions.
- Data for the combustion energy requirements of refinery processes that would expand to refine WCH and certain pollutant emissions associated with this fuel combustion are available from the literature, the U.S. Environmental Protection Agency, the U.S. Department of Energy, the California Air Resources Board, and environmental reviews of proposed hydrogen plants.
- This information indicates a range of potential emissions from combustion energy for the increase in vacuum distillation, coking and hydrogen needed to refine WCH efficiently. This range reflects the projected range of pipeline oil deliveries, the extent to which this pipeline's oil may add to or replace current refinery crude inputs, and limitations in the data noted above.
- Available data and information suggest that incremental greenhouse gas emissions from combustion energy inputs in just three processes at refineries running the heavier and more contaminated oil from the Keystone pipeline could range in the millions of metric tons per year.
- Shifting to WCH would further decrease the stability of refinery processes and, at the same time, increase the amounts of toxic and flammable gases at high temperature and pressure in refineries. This could, on average and over time, increase the frequency and magnitude of refinery upsets and imbalances

that require depressurizing process vessels by dumping the gases, and result in significant local emission incidents from burning off those gases in flares.

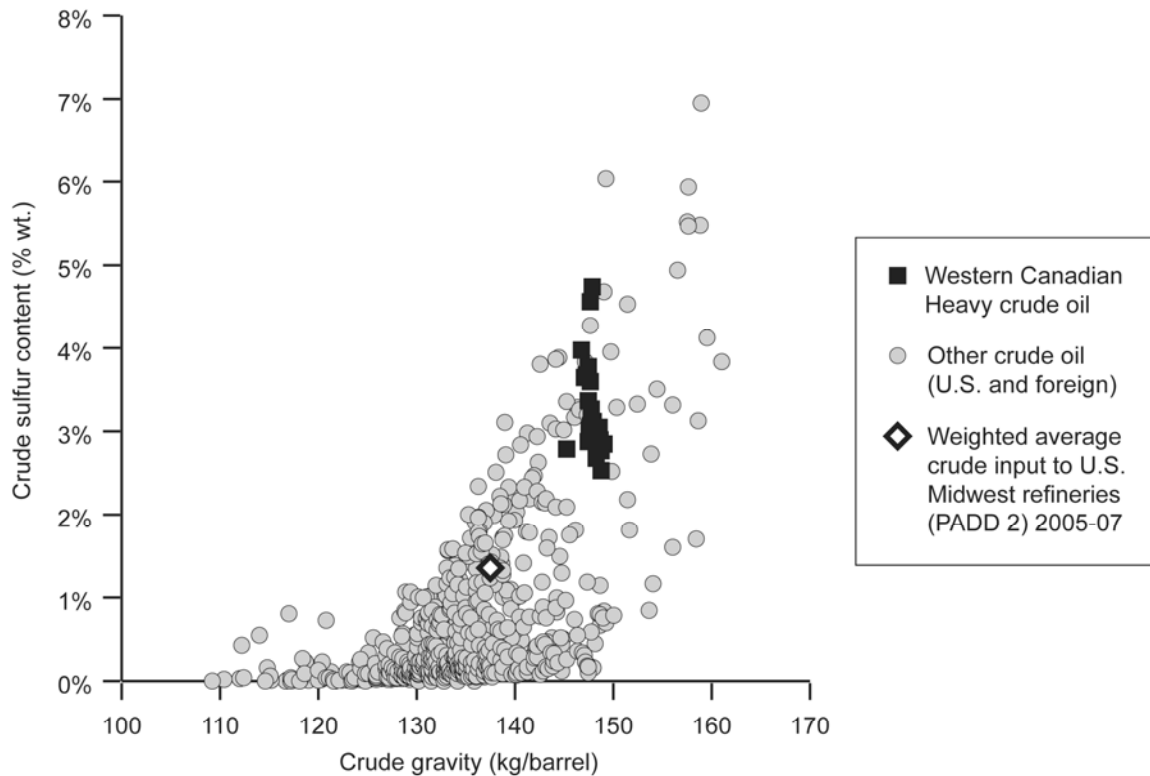
10. The FEIS and other documents I reviewed indicate that the Keystone pipeline will deliver heavy crude oil from the Western Canadian Sedimentary Basin, including oils derived from tar sands, for processing by refineries in the U.S. It will move the oil from a collection hub near Hardisty, Alberta, to Wood River and Patoka, Illinois, with a projected extension to Cushing, Oklahoma. Initial deliveries will be approximately 435,000 barrels per day (“b/d”) with a projected expansion to approximately 591,000 b/d. The FEIS also indicates that most of this oil will be processed at the Wood River, Illinois, refinery, with deliveries likely to other U.S. refineries, and that the pipeline is expected to operate for fifty years or more.

11. According to the FEIS, the oil that will be transported by the Keystone pipeline from the Western Canadian Sedimentary Basin is categorized as heavy crude oil (hereinafter “Western Canadian Heavy crude” or “WCH”).

12. There are some 20 named crude oils categorized as WCH. Some WCH oils are conventional crude oils while others are tar sands-derived bitumen/diluent blends. Tar sands are semi-solid deposits of sand and bitumen (tar) from which the bitumen must be separated from the sand during or after extraction and pre-processed before refining. The diluent, which may constitute approximately 30-50% of the blend sent through the pipeline, is liquid added to allow the viscous bitumen to be moved through pipelines from producing areas to refineries. A large collection system feeds WCH from producing areas to hubs near Edmonton and Hardisty. The U.S. Midwest is the largest WCH market and is expected to process much more WCH if pipeline capacity expands.

13. Compared with most crude oils worldwide, and with the mix currently processed by Midwest refineries,<sup>1</sup> WCH is heavier and higher in sulfur, as shown in Figure 1.

Figure 1. Gravity and sulfur content of Western Canadian Heavy v. other crude oils (785 oils).



Data from Can. Assoc. Petroleum Producers ([www.crudemonitor.ca](http://www.crudemonitor.ca)); U.S. Dept. of Energy (DOE: [www.netl.doe.gov/technologies/oil-gas/Software/database.html](http://www.netl.doe.gov/technologies/oil-gas/Software/database.html); post-1970 data); U.S. Energy Inf. Admin. (EIA: [http://tonto.eia.doe.gov/dnav/pet/pet\\_pnp\\_crq\\_dcu\\_r20\\_a.htm](http://tonto.eia.doe.gov/dnav/pet/pet_pnp_crq_dcu_r20_a.htm)); international crude vendors' on-line oil specifications; and Oil & Gas Journal Data Book. WCH data for oils < 25 °API.

### Refining characteristics

14. Figure 1 also reveals a general trend of higher sulfur content in heavier oils. The larger, denser hydrocarbon molecules that are more abundant in heavier crude oils (and make them heavier) also tend to have higher concentrations of sulfur, and other

<sup>1</sup> Herein, the term “Midwest refineries” means refineries in Petroleum Administration Defense District (“PADD”) 2, which includes Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Oklahoma, Tennessee, and Wisconsin. To avoid confusion, please note that some of the discussion in the FEIS appears to assign PADD numbers incorrectly.

contaminants. These characteristics, among others, are used to predict how a given crude oil must be processed to make the desired product slate. Those process conditions, in turn, affect pollutant release rates. Thus, the characteristics of WCH are central to the assessment of the Keystone pipeline's potential emission impacts.

15. A typical refinery will boil off and separate the components of crude oil by distillation. It will break or "crack" the larger hydrocarbons in the heavier oil streams from distillation into smaller molecules of the sizes needed for vehicle fuels. It will bond hydrogen to the cracked hydrocarbons to improve their burning properties in engines, and it will bond hydrogen to contaminants to remove them from the oil. It will, among other things, make the vast quantities of hydrogen that feeds these process reactions.

16. For a given amount of crude oil, the size of the equipment needed for many of these refining steps increases with the abundance of larger, heavier hydrocarbons in the oil, and with its sulfur content. For WCH oils, which have more of these heavier components and are grouped relatively closely in both gravity and distillation characteristics, the average is used in the description below.

17. The heavier components of crude oils boil off at higher temperatures than their lighter, lower-boiling components. Components boiling above about 650 °F can be distilled in a vacuum to produce useful "vacuum gas oil." Distillation data predict that approximately 60% of WCH would be processed in this way—by vacuum distillation.

18. Approximately 30% of WCH boils at very high temperatures above 1,050 °F and exits vacuum distillation as a viscous mixture of large hydrocarbon compounds called residua. To convert residua into engine fuel-size hydrocarbons it must be processed in a coker or similarly severe cracking process. As a result, refining WCH for transportation

fuels may require coking up to 30% of the WCH barrel. This is in addition to other cracking processes that run other WCH distillation streams such as gas oils.

19. After vacuum distillation and cracking, the partially processed oil streams need hydroprocessing. This is the reason why hydrogen is a major oil refining feedstock.

20. Coking and otherwise cracking the heavier components of oils such as WCH rejects hydrogen from these oil streams, which degrades their combustion properties. These streams also have more sulfur, which can poison some refinery process catalysts. Refiners bond hydrogen with the hydrocarbons in these streams to boost their hydrogen/carbon ratios and improve their combustion properties. Refiners also bond hydrogen with the sulfur, which is then separated from the oil as hydrogen sulfide gas, to remove contaminants from the oil. These hydroprocessing reactions proceed under heat and pressure in the presence of catalysts; some are designed for hydrogen addition, some for contaminant removal, and some are designed for both objectives. Hydrogen is required for all of these process reactions. Providing this hydrogen requires energy.

21. Conventional hydrogen production using steam methane reforming is the U.S. refining industry's technology of choice for add-on plants to feed their hydroprocessing. Steam methane reforming (SMR) separates hydrogen from methane mixed with steam in contact with a catalyst at processing temperatures around 1,500 °F. To produce this heat, SMR burns large amounts of fuel, which causes greenhouse gas emissions.

22. According to published literature, hydrogen inputs required to process the heavier products of vacuum distillation and cracking are several times those for the lighter liquid streams that are produced in larger amounts from distillation of lighter crude oils. The higher levels of contaminants such as sulfur in WCH require still more hydrogen.

23. Refining WCH for transportation fuels could require producing roughly 900 cubic feet of hydrogen per barrel of WCH refined. This is based on hydrogen/oil ratios reported by Robinson and Dolbear, a sulfur correction reported by Ancheyta, the WCH distillation characteristics cited above, and an average WCH sulfur content of 3%. It also assumes hydroprocessing gas oil produced by coking WCH residua streams rather than hydroprocessing the residua; hydroprocessing residua may require more hydrogen than suggested by this estimate. By comparison, the five major refineries in the San Francisco Bay Area run a mix of medium gravity and heavy crude oils with about 1.5% sulfur and produce approximately the same amount of hydrogen (~900 cf/b).

#### **Refinery observations**

24. WCH has already affected the Midwest refiners' crude input shown in Figure 1. Some 677,000 of the 3.24 million barrels/day (b/d) refined in the Midwest during 2007 were WCH. Based on Energy Information Administration (EIA) data, Midwest refineries that process more WCH have more capacity for vacuum distillation, coking, and sulfur recovery on average than those that process less WCH. Moreover, plants that process more WCH consume significantly more hydrogen. These observations are consistent with the process changes predicted from the refining characteristics of WCH.

25. These EIA data suggest that 14 Midwest (PADD 2) refineries ran WCH as a significant portion of their total crude input in 2007 (more than 7,000 b/d each; collectively 27% of total input) while the other 12 ran little or no WCH (0-2,000 b/d each; collectively 0.3% of input). Vacuum distillation capacity averaged 26% of total crude input capacity for the 12 refineries that ran little or no WCH versus 47% for the refineries that ran WCH as 27% of their total combined crude input capacity. Refining

100% WCH could require vacuum distillation for 60% of the WCH barrel, based on WCH refining characteristics.

26. Similarly, coking capacity averaged 4% of crude input capacity at refineries that ran little or no WCH versus 14% for those that ran more WCH. (Refiners running 100% WCH for vehicle fuels may coke 30% of the barrel as discussed above.) Refiners that ran little or no WCH had only half as much sulfur recovery capacity on average as those that ran more WCH. (The average Midwest crude input has about half the sulfur of WCH.)

27. Applying the hydrogen/oil ratios and sulfur correction cited above to the hydroprocessing capacities of these plants suggests refiners running WCH as 27% of their crude input require an average of 70 cf/b more hydrogen than those running little or no WCH. This observation results in an estimated hydrogen requirement of 860 cubic feet per barrel WCH refined, or 260 cf/b more than that for running little or no WCH. This estimate using observed processing capacities (860 cf/b) is close to what is predicted from WCH characteristics and observed from Bay Area refineries (~900 cf/b).

28. The American Petroleum Institute (API) website advises that refiners planning to process tar sands-derived WCH consider expanding their vacuum distillation, coking, hydroprocessing, hydrogen production, and sulfur recovery capacities.

29. The FEIS reports that the Wood River, Illinois refinery is expanding these same five processes in connection with processing the “high-acid, high sulfur, heavy crude” oil to be delivered by the Keystone pipeline. According to the Oil & Gas Journal, the refinery has begun building the 65,000 b/d coker component of this expansion.

30. Oil & Gas Journal’s worldwide construction updates indicate that even before the current capacity expansion, the Wood River refinery was building 3,000 b/d of expanded

31. By 2015 the Wood River refinery plans to build 400,000 b/d of Canadian heavy crude capacity, with 200,000 b/d of this as bitumen processing capacity, according to a 10-K report filed with the Securities and Exchange Commission by ConocoPhillips, and an October 5, 2006 business news report released by EnCana Corporation. These ConocoPhillips and EnCana reports also indicate that the WRB Borger refinery<sup>2</sup> plans by 2015 to build 150,000 b/d of Canadian heavy crude capacity with 75,000 b/d of this as bitumen capacity.

32. WRB's Borger refinery was building 75,000 b/d of new vacuum distillation capacity, 25,000 b/d of new coking capacity, and 25 million cubic feet/day of new hydrogen production capacity between 2005 and 2007, according to the Oil & Gas Journal construction updates.

33. The "NCRA 2007 Annual Report," which appears to be the National Cooperative Refinery Association's annual report to shareholders, indicates that NCRA has entered into an agreement to receive an additional 20,000 b/d of heavy crude oil from Canada through the Keystone Pipeline for processing at NCRA's McPherson, Kansas refinery. The McPherson refinery was building 35,000 b/d of new hydrocracking capacity and 75 million cubic feet/day of new hydrogen production capacity, and retooling its existing hydrotreating capacity in 2004 and 2005, according to the Oil & Gas Journal construction reports.

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<sup>2</sup> WRB is the acronym for Wood River Borger, a venture of ConocoPhillips and EnCana. The Borger refinery is in the Texas Panhandle, in PADD 3 and bordering on Midwest PADD 2.

34. A Kansas Department of Health and Environment permit in effect for the McPherson refinery in 2005 describes proposed modifications. These included: “the installation of an FCC feed severe hydrotreating unit (Unicracking Unit) designed to remove sulfur and nitrogen from the gas oil feed, a steam reforming unit (Hydrogen Unit) to supply hydrogen for hydrotreating, [and] a Sulfur Recovery Unit to recover the additional sulfur from severely hydrotreating gas oil and distillates.” Coking, vacuum, and other hydroprocessing units were also modified. Some of these process expansions appear to be the same ones that the Oil & Gas Journal reported under construction.

35. Altogether, the Wood River, Borger and McPherson refineries might refine a total of roughly 590,000 b/d of WCH by 2015, according to these reports. This would be an increase of roughly 520,000 b/d capacity for WCH delivery by the Keystone pipeline, and compares with the pipeline’s capacity of 435,000-591,000 b/d. It would add substantially to the 677,000 b/d refined by Midwest refineries in 2007.

### **Greenhouse gas emissions**

36. Expanding processes and production rates will increase energy requirements for these refineries, resulting in the combustion of more fuel to supply refinery process energy, and increased pollutant emissions from the combustion of that fuel.

37. The State Department could have analyzed the emissions expected from burning fuel to supply the additional energy requirements of refining WCH delivered by the Keystone pipeline. One way to do this, for example, is to determine the processing changes expected to refine this oil, the energy requirements of that processing, and then the emissions from burning fuels to supply those energy requirements. Even a limited search found estimated energy requirements for vacuum distillation (U.S. EPA, 1995),

delayed coking (Feintuch et al., 1986), and conventional hydrogen production by SMR (U.S. DOE NETL, 2002), as well as greenhouse gas emissions per unit combustion energy (Cal. ARB, 2007). Options for determining the process changes connected to such energy requirements and emissions are discussed below.

38. Refiners planning to process a new oil use data on its characteristics, technical reference literature and general knowledge on refining oil with similar characteristics, and observations from plants already running the new oil to assess processing changes. This, in essence, describes much of the preliminary assessment above. WCH average distillation characteristics predict needed vacuum distillation, coking and hydrogen capacities (60% of the barrel, 30% of the barrel, and 860 cf/b WCH respectively). Also, observations of refineries that run and/or plan to run WCH and other oils support these predictions. The State Department could have done such an assessment.

39. Alternatively, government environmental reviewers have often requested details of planned refinery process changes from refiners. Some information about the Wood River, Borger and McPherson projects is available. These plants are building or planning process expansions that are consistent with those predicted by the characteristics of WCH, and with observations from plants already running WCH. Nevertheless, additional relevant details have been reported publicly for some other planned refinery expansions, and it is likely that detailed designs have been developed for these refiners' projects. The State Department could request process design details from the companies.

40. The State Department could use these and other data to estimate emissions associated with refining the oil that the pipeline will carry in various operating scenarios. For example, it could estimate greenhouse gas emissions from fuel combustion for the

direct energy inputs to vacuum distillation, coking and hydrogen production to refine WCH from the pipeline. It could assume one scenario in which the pipeline delivers its maximum estimated capacity of 591,000 b/d and all of this WCH is added to the existing crude oil inputs processed by U.S. refineries. It could assume the process capacities described above for WCH refining: 60%/b, 30%/b and 860 cf/b for vacuum distillation, coking and hydrogen plants, respectively. In this scenario, emissions could increase by approximately 5.4 million metric tons per year, as carbon equivalent.

41. The State Department could then assume a second scenario in which the pipeline delivers at its initial capacity of 435,000 b/d and all of this oil replaces current U.S. refinery crude inputs barrel for barrel. In this scenario emissions from the oil to be replaced would be subtracted from those for refining Keystone oil. The State Department could assume that the current average capacities of refiners processing little or no WCH represent the oil to be replaced. Impacts from this second scenario would then be related to 34% of the crude input barrel for vacuum distillation (60-26%), 26% for coking (30-4%) and 260 cf/b for hydrogen plants (860-600 cf/b). In this scenario, emissions could increase by approximately 1.5 million tons/year carbon equivalent.

42. The State Department could double-check estimates developed in this manner by comparing them to other sources of information, such as the actual processing capacity being added by individual refineries that will process Keystone oil and data on hydrogen production and greenhouse gas emissions from analogous process sources. For example, the greenhouse gas emissions estimated above are largely driven by hydrogen production emissions. The hydrogen emissions per unit production used in the estimates above are roughly comparable to those for two proposed new hydrogen plants evaluated recently.

43. These scenarios assume natural gas combustion, and account for only the energy demands of vacuum distillation, coking, and hydrogen plants. Because refineries burn other fossil fuels that have higher greenhouse gas emissions per unit of energy produced, and emit from additional sources, the State Department could find that refining Keystone oil emits greenhouse gases in excess of the estimates outlined above.

44. The greenhouse gas emissions associated with using WCH, especially WCH derived from tar sands, are not limited to refineries. Brandt and Farrel estimate emissions from oil extraction, intermediate processing, refining, and tailpipe emissions. They find that the share of overall greenhouse gas emissions attributable to oil production and refining, as opposed to tailpipe emissions, could increase from 22% for gasoline made from conventional oil to as much as 44% for gasoline made from tar sands. Because tailpipe emissions are among the largest national and global sources of greenhouse gas emissions, these figures provide important context for the estimates above.

### **Flare pollution incidents**

45. Refining WCH could increase the inherent hazard of oil refining by increasing the frequency of process upsets, the volumes of toxic and flammable gases involved in such upsets, and the frequency and magnitude of emission incidents. Inherent hazards that cause refinery upsets include, among others, equipment malfunctions caused by acid corrosion, and unstable process conditions caused by the need to clean or change out process catalysts poisoned by contaminants from crude oil.

46. The FEIS suggests that refining Keystone pipeline oil could increase the acidity of process inputs at the Wood River refinery. The median total acid number (TAN) of WCH oils is in the top 12% of crude oils, based on available data. This further suggests

that refining WCH is likely to increase acid corrosion in the refineries that will use Keystone pipeline oil. Preventive actions such as changing the metallurgy of equipment can address some of the potential impacts. However, the corrosivity of an acidic crude oil can be expressed in various locations within a refinery, some of which may be hard to predict in advance, so equipment malfunctions could occur despite such precautions.

47. Contaminants in WCH that can poison refinery process catalysts include, among others, sulfur, nickel and vanadium. The median sulfur content of WCH is twice that of the weighted average Midwest crude input. The median concentration of nickel-plus-vanadium in WCH is in the top 10% of crude oils for which these data are reported. Switching to WCH would increase catalyst loading in Midwest refineries.

48. Increased catalyst loading from contaminants in WCH will, on average, require the affected process units to be shut down more often for catalyst replacement or reconditioning. This will, in turn, increase the frequency of unstable or unbalanced processing conditions that are prone to upset. Refineries are most stable when operating in steady state conditions or shut down, and more prone to upset when process units are ramping up and down during startups and shutdowns.

49. When malfunctions or planned shutdowns occur, WCH will tend to increase the volume of toxic and flammable gases released. Its higher sulfur content will produce larger volumes of these gases in hydroprocessing units. Further, the additional cracking needed to process WCH will produce more hydrocarbon gases as byproducts.

50. Shutdowns require depressuring units—quickly discharging the large volumes of gases contained at high temperatures and pressures in the vessels where process reactions occur. When a unit must be depressurized quickly for any reason, gases discharge

through large valves called pressure relief valves (PRVs). Old designs still used in some places vent PRVs directly to the air. Current designs pipe PRVs to control systems such as flares. Although data to confirm this were not available, the less polluting design using flaring is assumed herein.

51. Flaring is the combustion of excess gases and entrained liquids in an open flame using oxygen from the ambient air. Flares are safety devices intended for unforeseen emergencies that require dumping gases to relieve over-pressurized vessels. Flares are connected to a refinery's process units by a flare gas system, which is separate from its fuel gas system. During normal operation when the refinery is in balance, the fuel gas system recovers nearly all gases produced, for use as refinery fuel. The flare gas system is designed for upset conditions. It is typically sized for the worst-case emergency.

52. A refinery flare gas system is typically designed to recover only limited amounts of gases and flare the rest. San Francisco Bay Area refiners' flare gas recovery capacities are only about one tenth of their total fuel gas flows. Process upsets, and even planned maintenance shutdowns routinely cause significant flaring at many refineries. Both catalyst-related shutdowns and upsets caused by refining WCH could cause flaring.

53. Increased flaring related to the refining of heavier and/or higher-sulfur crude oils is reported in two U.S. refining regions.

54. In the San Francisco Bay Area, four refiners that flared from hydroprocessing units emitted higher sulfur dioxide concentrations when the sulfur content of their crude inputs increased by 0.5% during the month leading up to the flaring. (Hydroprocessing removes sulfur from oil as hydrogen sulfide gas, which forms sulfur dioxide when flared.) Further investigation of all processes at one of the plants showed that the

frequency of significant flaring more than doubled as crude sulfur increased by this same 0.5% increment. By comparison, WCH is about 1.5% higher in sulfur than the current weighted average of PADD 2 refinery inputs.

55. Increased flaring frequency and magnitude following a shift to heavier and higher sulfur crude oil inputs is also reported among refineries on the U.S. Gulf Coast.

56. Flaring can cause localized high-concentration plumes of air pollutants during the hours or days when it occurs, resulting in acute exposures of refinery workers and nearby residents to these pollutants. Based on measurements and modeling of flare plumes, the Bay Area Air Quality Management District found that flaring more than 500,000 cubic feet of process gases per day and/or flaring that emits more than 500 pounds of sulfur dioxide per day could negatively impact air quality in nearby communities.

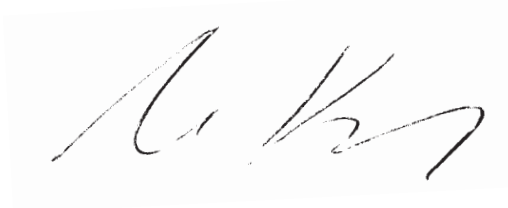
57. Data show that flaring by the five Bay Area refineries exceeded this significance threshold on a combined total of 677 days during 2004 through 2006. Flaring frequency and magnitude varies from one refinery to another. Data on flaring patterns at the Wood River, Borger and McPherson refineries were not available for this assessment.

58. This assessment is limited to selected causes of greenhouse gas and flare emissions from U.S. refineries. Further, though sufficient for preliminary assessment, the available data are limited. More complete data for: WCH and current refinery input oil quality, oil specifications in signed delivery contracts, vacuum distillation and coking energy requirements, fuels burned for energy by refiners that would process Keystone pipeline oil, and process design and flare system details of the refineries where projects are planned or built to process this oil could improve and build on this preliminary

assessment. More complete data of each kind listed above likely exist and could be found by additional focused investigation.

I declare under penalty of perjury that the foregoing is true of my own knowledge, except as to those matters stated on information and belief, and as to those matters, I believe them to be true.

Executed this 17th day of October 2008 at Oakland, California.

A handwritten signature in black ink, appearing to read "G. Karras", is written on a light-colored rectangular background.

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Greg Karras