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# **Potential Economic Consequences from an Event at the San Onofre Nuclear Generating Station (S.O.N.G.S.) Interim Spent Fuel Storage Facility**

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## Abstract

The San Onofre Nuclear Generating Station (S.O.N.G.S.) operated for 44 years from 1968 to 2012. Its Interim Spent Fuel Storage Facility remains, located next to the Pacific Ocean along Interstate 5 between San Diego and Orange County. A significant release of nuclear material there could impact one of the most populated regions in the U.S. out to a range of 50 miles. This analysis examined the economic effects on a three-county region, with a specific look at prominent local industries including tourism and the largest port complex on the West Coast, as well as loss of residential real estate value. In a scenario looking at contamination across a one-mile radius, the most significant loss likely is disruption of the regional transportation network for up to a year costing \$266 million. Scenarios were assessed for evacuation zones of 10 and 50 miles, looking at impacts for one and 50 years. Residential property losses could amount to \$11 to \$500 billion depending on the evacuation scenario, and the loss in annual gross regional product could range from \$6 to \$500 billion. In the 50-mile impact scenario, about \$13.4 trillion in gross regional product could be at risk over a 50-year time horizon. These potential catastrophic losses are at least ten times larger than present levels of insurance against these types of events.

## Introduction

The first unit of the San Onofre Nuclear Generating Station (S.O.N.G.S.) began operation in 1968, and second two units closed in 2012 after thousands of leaks were discovered in the plants' steam generator tubes. The S.O.N.G.S. Spent Fuel Storage Facility is located adjacent to the now-closed plant site on the ocean side of Interstate 5 in San Onofre, California.

A significant release of nuclear material at the Interim Spent Fuel Storage Facility, located along the Pacific Coast, has the potential to impact a large swath of Southern California. The economic impact would depend on the scale and the duration of any evacuations or impairments to infrastructure and economic activities. This memo outlines what we know about the potential impacts and provides estimates of the conceivable economic impact of a nuclear disaster at S.O.N.G.S. under a range of scenarios.

## Economic scale of the Southern California region

Located in Orange County adjacent to U.S. Marine Camp Pendleton and Interstate Highway 5 (I-5) the S.O.N.G.S. facility has the potential to impact the three coastal counties of San Diego, Orange County, and Los Angeles. These are the three most populous counties in the state—their combined population makes up 42% of Californians. The Los Angeles-Long Beach-Anaheim Metropolitan Statistical Area (MSA) has a regional GDP of \$1.00 trillion and ranks as the 2<sup>nd</sup> largest metropolitan economy in the US. The San Diego-Carlsbad MSA has a regional GDP of \$215 billion and ranks 17<sup>th</sup> in the US.<sup>1</sup> Out of the \$2.75 trillion California economy, these make up 36% and 8%, respectively.

Residential housing values in coastal Southern California are more than 160% higher than the national average, according to the Zillow Home Value Index as of August 2018. The housing stock value of \$1.44 trillion represents 14.7% of the total national value, with 5.7% of stock.

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<sup>1</sup> Gross Domestic Product by Metropolitan Area, 2017. Bureau of Economic Analysis.  
<https://www.bea.gov/data/gdp/gdp-metropolitan-area>

## Drawing Lessons from Fukushima Tsunami Disaster Impacts

The recent nuclear disaster at the Fukushima Facility in Japan in 2011 provides a useful example of the evacuation scenarios and economic impacts that are possible after a nuclear disaster. Fukushima is not a clear-cut example because the nuclear disaster at the Fukushima Daiichi plant was preceded by an earthquake and tsunami that already created a massive humanitarian and economic toll before the nuclear event. However, it does provide a useful example of the potential scale of a nuclear disaster in terms of geography, reach and duration.

Waves from the March 2011 tsunami damaged the Fukushima nuclear power plant and caused a leak of radioactive material. On the International Nuclear Event Scale, Japan classified this disaster at a “seven,” which means it was a “major release of radiation, with widespread health and environmental effects.” The first evacuation was within a 2 km (1.2-mile) radius of the Daiichi plant the same day as the tsunami. The next day the evacuation expanded to 10 km (6.2 miles), and further to 20 km (12.4 miles) after high radiation levels were recorded at the site.<sup>2</sup> Initially, about 45,000 people were evacuated from Fukushima. That number increased to a peak of over 60,000 people in late 2011. The number of evacuees has steadily decreased over time as people return to the area, however, according to Fukushima Prefecture, as of early 2018, there are still approximately 35,000 evacuees who have yet to return home. One estimate puts the number of people affected by the nuclear accident at 32 million.<sup>3</sup>

In 2017, the Japan Center for Economic Research found that the total cost of the Fukushima disaster could reach \$626 billion, including the cost of compensating victims, clean-up costs, decontamination, interim storage of contaminated materials, and decommissioning the plant.<sup>4</sup>

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<sup>2</sup> Robin Harding, “Fukushima nuclear disaster: did the evacuation raise the death toll?” *Financial Times*, March 10, 2018. <https://www.ft.com/content/000f864e-22ba-11e8-addone-0e8958b189ea>

<sup>3</sup> Jonathan M. Samet and Dayana Chanson, “Fukushima Daiichi Power Plant Disaster: How many people were affected? – 2015 Report,” [https://www.greencross.ch/wp-content/uploads/uploads/media/2015\\_fukushima\\_report.pdf](https://www.greencross.ch/wp-content/uploads/uploads/media/2015_fukushima_report.pdf), March 9, 2015.

<sup>4</sup> ‘Real cost of Fukushima disaster will reach Y70 trillion, or triple government’s estimate: think tank’, *The Japan Times*. April 1, 2017. <https://www.japantimes.co.jp/news/2017/04/01/national/real-cost-fukushima-disaster-will-reach-%C2%A570-trillion-triple-governments-estimate-think-tank/#.W6GMIs5KhD8>

The cost of cleanup at the site alone was estimated in 2016 to be \$180 billion.<sup>5</sup> In addition, supply chain networks throughout Japan were impacted by the evacuation of entire communities as well as infrastructure losses. Further, the disaster triggered a national policy decision to close all of its nuclear power plants for two years, and to only restart a limited number.<sup>6</sup> Japan chose to seek alternative energy sources, including more fossil fuel usage, on short order.

For comparison, the Chernobyl nuclear power plant disaster in Ukraine in 1986 affected over 18,000 square miles (which implies a radius of at least 75 miles). The total cost estimated by the Belarus Foreign Ministry is \$235 billion over 30 years, with 1.3 million individuals impacted.<sup>7</sup>

## Analysis of Economic Consequences

A major disaster at the S.O.N.G.S. Interim Spent Fuel Storage Installation would have the potential to impact several major economic sectors in the affected counties, including transportation, port closures, tourism, and real estate, as part of shutting down normal commercial activity. We use IMPLAN economic impact modelling software to estimate the overall economic activity in the impact area that would be curtailed due to a large-scale evacuation. The IMPLAN data includes all commercial and household economic activity that takes place in the affected zip codes. To get a more comprehensive picture of the impacts, we also look specifically at some of the large economic sectors that would be impacted by a large-scale disaster. These will be discussed individually in the sections below.

IMPLAN is a widely-accepted economic analysis tool used to value the net income and employment activity for economic sectors. Input-output models such as IMPLAN use area-specific data on industrial and commercial activity to trace how a dollar of investment moves through a regional economy. These models are commonly used to evaluate economic

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<sup>5</sup> "Japan Fukushima nuclear plant 'clean-up costs double," *BBC News*, <https://www.bbc.com/news/world-asia-38131248>, November 28, 2016.

<sup>6</sup> Takamitsu Sawa, "The future shape of Japan's energy policy," *Japan Times*, <https://www.japantimes.co.jp/opinion/2018/07/12/commentary/japan-commentary/future-shape-japans-energy-policy/>, July 12, 2018.

<sup>7</sup> Belarus Foreign Ministry, "CHERNOBYL disaster: Why are the consequences still observed? And Why is the international assistance still critical?", [http://chernobyl.undp.org/russian/docs/belarus\\_23\\_anniversary.pdf](http://chernobyl.undp.org/russian/docs/belarus_23_anniversary.pdf), April 2009.

activity in which changes in the total demand for output of the industries being studied results in changes in inputs and outputs by the local economic sectors.<sup>8</sup> For example, these models have been used to estimate the impacts of such projects as construction and operation of new factories, development of tourism facilities, and military base closures.

For all the economic impacts, we consider several basic scenarios. Geographically, we look at the impacts of a total evacuation within a one-mile radius, a 10-mile radius, and a 50-mile radius. The one-mile radius represents a relatively minor event, but because of the S.O.N.G.S. facility's location, it would include the I-5 highway and rail corridor. The 10-mile radius is consistent with the Emergency Planning Zone (EPZ) directed by the Nuclear Regulatory Commission (NRC), and represents the plume exposure pathway, where predetermined protective action plans are in place to reduce harmful exposure to radioactive material.<sup>9</sup> The 50-mile radius represents a more serious event. For example, in 2011, after the Fukushima nuclear disaster, the Nuclear Regulatory Commission advised Americans residing in Japan to evacuate within a 50-mile radius.<sup>10</sup> The 50-mile radius is designated by the NRC as the ingestion exposure EPZ. These two ranges provide a range of potential impacts beyond the localized ones that would be associated with an event affecting a one-mile radius. We consider a one-year duration of impacts, as well as a 50-year duration to capture the potential time range of contamination.<sup>11</sup>

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<sup>8</sup> See Appendix A for more detail on the IMPLAN model.

<sup>9</sup> "Emergency Planning Zones". US Nuclear Regulatory Commission.

<https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html>

<sup>10</sup> "Emergency Planning Zones". US Nuclear Regulatory Commission.

<https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html>

<sup>11</sup> Due to the effects of discounting future economic activity in the standard economic analytic method used here, the lost value more than 50 years in the future is de minimis

## Sector-Specific Impacts

### Port Closures

The 50-mile exposure zone for the S.O.N.G.S. Interim Spent Fuel Storage Installation would include the Ports of Los Angeles and Long Beach. In total domestic and international trade, these ports rank 9<sup>th</sup> and 7<sup>th</sup>, respectively, among all US ports by tonnage and make up 5% of total. For this analysis, we estimate the cost of closing these two ports based on studies of past port closures. In 2015, the ports of Los Angeles and Long Beach were closed for 11 days over a 12-day period due to a labor dispute. A range of analyses have estimated the economic cost of this closure, with estimates ranging from \$1.9 billion to \$19.4 billion.<sup>12</sup> The Congressional Budget Office (CBO) arrived at a relatively conservative estimate of the cost of a one-week shutdown of the ports of Los Angeles and Long Beach, finding that it would cost the US economy \$65 million to \$150 million a day.<sup>13</sup> Using this range and extrapolating out to a closure that lasts for one year, we estimate the total economic cost at \$23.7 billion to \$54.7 billion, as shown in Table 1. The CBO estimates are for a one-week shutdown. However, the costs of a longer-term shutdown would likely be mitigated somewhat by longer-term adjustments. We show the potential impacts of a 50-year closure in Table 1 as well. We therefore use the lower end of the estimates of \$23.7 billion as our benchmark of the impact of port closures for a year. The cost of these port closures is subsumed into the overall IMPLAN impact analysis described further below.

**Table 1. Port Closure Range of Economic Impacts (\$ Billions)**

Period	Low End	High End
<b>1 year</b>	\$23.7	\$54.7
<b>50 years</b>	\$633.6	\$1,461.9

<sup>12</sup> Bonney, Joseph. 'Putting a Price on a Port Strike'. The Journal of Commerce. JOC.com. [https://www.joc.com/port-news/longshoreman-labor/international-longshoremen%E2%80%99s-association/putting-price-port-strike\\_20130215.html](https://www.joc.com/port-news/longshoreman-labor/international-longshoremen%E2%80%99s-association/putting-price-port-strike_20130215.html), February 15, 2013.

<sup>13</sup> Ibid.



In addition, a 50-mile radius from the S.O.N.G.S. facility would also include the smaller Port of San Diego. Since there are no reliable estimates of the economic cost of a port closure in San Diego, we do not explicitly call this out in this analysis, resulting in a more conservative estimate. However, to the extent that Port of San Diego activities are captured in the 50-mile radius event analysis, those are included in the IMPLAN results.

## Tourism

While the tourism industry is included in the general economic activity that is analyzed in IMPLAN economic modelling, considering that Los Angeles and San Diego are among the top tourist destinations in the US, it is worth understanding this impact separately.

A look at the total county-wide tourism economy in 2016 is provided below in Table 2. Tourism contributes \$23 billion to Orange and San Diego counties, and nearly \$2 billion in tax revenues.

**Table 2. 2016 Tourism Economy Statistics (\$ Billions)**

	Employment	Economic Activity	Tax Revenue
<b>Los Angeles</b>	1,000,000	\$126.3	\$10.3
<b>Orange County</b>	164,000	\$12.1	\$1.1
<b>San Diego</b>	194,000	\$10.8	\$0.8

Source: San Diego: <https://www.sandiego.org/about/industry-research.aspx>;

Orange County: [http://www.oc-breeze.com/2017/04/18/99980\\_visitor-numbers-orange-county-hit-new-records-2016/](http://www.oc-breeze.com/2017/04/18/99980_visitor-numbers-orange-county-hit-new-records-2016/);

Los Angeles: <http://www.latimes.com/business/la-fi-ca-economic-impact-20170504-story.html>

A majority of Orange County is covered in the 50-mile scenario, most importantly along the Pacific Coast, so we assume that the entire tourism industry would be impacted there. This includes the famous tourist destinations in Anaheim such as Disneyland and its environs. We also assume that the entire tourism industry in San Diego will be impacted under the 50-mile scenario. In San Diego, only a portion of the county would be covered by the 10-mile and 50-mile

radius. However, a 50-mile event would cut off Interstate 5 and Interstate 15, the major driving routes to San Diego from the northern parts of the state. In addition, the 50-mile radius includes San Diego International Airport, which if closed would effectively cut off travel from international and distant US locations.

Los Angeles County would only be impacted under the 50-mile scenario, and then only 6% of total land area would be impacted, mostly at the southern edge near the Port of Los Angeles, away from most major tourist destinations in that county. We therefore conservatively consider that tourism impacts for LA County would be minimal. We therefore use 100% of the total tourism economic benefit in Orange County and San Diego County as the impact under the 50-mile scenario. We assume a tourism impact of zero for Los Angeles County. These results are shown in Table 3.

**Table 3. Tourism economic Impact under 50-mile scenario per year (\$ Billions)**

	Economic impact
<b>Los Angeles</b>	N/A
<b>Orange County</b>	\$12.1 / year
<b>San Diego</b>	\$10.8 / year

As with the port closures, the loss in tourism activity is incorporated into the IMPLAN analysis summarized below.

### Real Estate Assets

During an extended evacuation due to an emergency event, the loss of value in the stock of real estate in the affected areas could be considered an economic cost. This cost differs from the losses attributable to decreased economic activity, which are measured as annual financial flows. This is especially the case for a 50-year duration event. The impact on business property value is best estimated as the loss of future income measured through the gross regional product (GRP) over an extended period, e.g., 50 years. No commercial, institutional, or

government real estate values are included in this report, and only residential real estate values are calculated.<sup>14</sup>

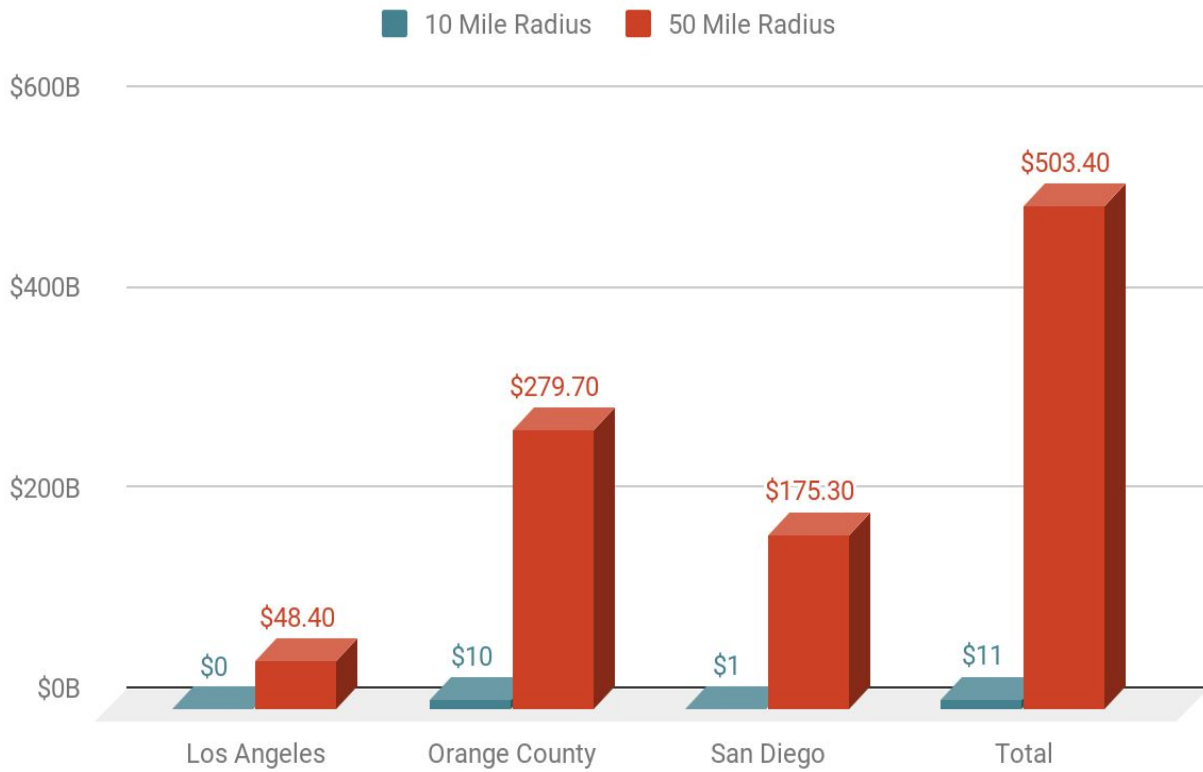
We estimate the total residential real estate value that is within the 10- and 50-mile radii of the S.O.N.G.S. Interim Spent Fuel Storage Installation based on the average assessed real estate values in each impacted county as a whole. We relied on the Zillow Z-estimate values for 2018<sup>15</sup> as a more reliable metric of actual market values, instead of the county-level assessed real estate values from the California Board of Equalization published tables<sup>16</sup> tables which do not reflect the full escalation in market prices since the passage of Proposition 13 in 1978. The Zillow data provides value by ZIP code, facilitating estimates by distance from the S.O.N.G.S. Interim Spent Fuel Storage Installation. See Table 4 for the breakdown total real estate values by the affected portion of land area. A total evacuation of these zones implies that this value would be lost entirely. For the 10-mile scenario, the value impacted is \$11.2 billion. For the 50-mile radius scenario, it is \$503.4 billion.

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<sup>14</sup> Calculating the true market value of commercial and institutional property values *en masse* by zip code was determined to be beyond the resources available for this project and requires increased computing and data base access. (And we still would miss the value of government facilities because they are not assessed for tax purposes and are not readily transacted in the market place.) However as noted in the text, commercial property value loss is implicitly included in the 50-year scenarios because the value of that land is derived entirely as a portion of the net income to the commercial/industrial activities on that land—no activity, no value. We do not have a measure of the portion of that net income that accrues to real estate value versus other agents such as shareholders and proprietors. That analysis is conducted with the IMPLAN regional impact model discussed in the section below. Nevertheless, the loss of real estate value is not considered an economic impact in the standard definition as it is a loss of wealth which may not have a direct effect on economic activity. This is a separate measure that illustrates the asset value that is at risk in this situation.

<sup>15</sup> Zillow Research, op. cit.

<sup>16</sup> Table 10-Net State - and County-Assessed Value of Property Subject to General Property Taxes on the secured and Unsecured Rolls, by County. California State Board of Equalization.  
<http://www.boe.ca.gov/annual/table10.htm>

**Table 4. Estimates of Residential Real Estate Values (\$ Billion)**

## Measure of Potential Regional Economic Impacts

### Impacts to a one-mile radius

Estimating the impacts for the area within one-mile of the S.O.N.G.S. facility requires speculative assumptions about responses to closure of the I-5 corridor transportation network. A review of the economic activity data within the ZIP code that encompasses S.O.N.G.S. shows that there would be negligible impacts to the regional economy. The I-5 corridor carries significant amounts of daily traffic and freight, both vehicular and rail, between the Orange and San Diego Counties metropolitan areas,<sup>17</sup> but those regions are also connected via I-15 and other inland routes. While I-5 would be disrupted for a period time, without substantial

<sup>17</sup> I-5 carries an average of 145,000 vehicles per day on that stretch (Caltrans, "Traffic Census Program," 2016 Data, <http://www.dot.ca.gov/trafficops/census/>, retrieved July 2018.)

transportation network modeling it is not possible to estimate the economic consequences with the tools used here.<sup>18</sup>

How the state would respond to the closure of I-5 is not known. However, California did learn from its slow response to the 1989 Loma Prieta earthquake that affected the San Francisco Bay Area by quickly jumping to action after the 1994 Northridge earthquake in Los Angeles. The I-10 Santa Monica Freeway collapsed, forcing the rerouting of an average 341,000 vehicles per day. The lost business due to its closure was estimated at \$1 million per day (\$1.7 million in 2018 dollars).<sup>19</sup> The state issued an incentive-based contract that brought repair of the highway within 66 days at a cost of \$30 million.<sup>20</sup> We could expect a similar effort if the highway appears to be closed for a prolonged period.

If we assume that the travel cost delays from congestion and rerouting are of similar magnitude per vehicle as experienced after the Northridge earthquake, we can provide a ballpark estimate for a one-year closure of I-5.<sup>21</sup> Scaling the I-10 daily impacts to the traffic volume on I-5 in 2018 dollars leads to an estimated regional cost of \$730,000 per day. Over a one-year period, that would cost \$266 million.

If the closure was expected to be over a long duration, we expect that (1) alternative routes would be constructed at an unknown cost, and (2) households would relocate to avoid crossing the area on a regular basis. For example, an individual working in Santa Ana who lived in Carlsbad would likely either find a job in San Diego County or move to Orange County. Given that households likely would swap positions, it is not possible to estimate the costs from those relocations.

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<sup>18</sup> Based on the SANDAG Gateway Study, a relatively small amount of freight is hauled via rail between San Diego and Los Angeles. Most freight appears to be hauled via truck, some of which is moved by intermodal with a transfer to or from rail in Los Angeles. (See CDM Smith and San Diego Rail Consulting, "Draft 2015 Freight Gateway Study Update," Prepared for SANDAG, September 2015.) Due to the multiple trucking corridors, we propose the disruption measurement method discussed here as the preferred mode of estimating the economic costs to freight hauling.

<sup>19</sup> Peter Phillips, "Lessons for post-Katrina reconstruction: A high-road vs. low-road recovery," *Economic Policy Institute*, <https://www.epi.org/publication/bp166/>, October 6, 2005.

<sup>20</sup> *Ibid.*

<sup>21</sup> Larry Wesemann, Tijana Hamilton, Steve Tabaie, and Gerald Bare, "Cost-of-Delay Studies for Freeway Closures Caused by Northridge Earthquake," *Transportation Research Record: Journal of the Transportation Research Board*, 1559:67-75, <https://trrjournalonline.trb.org/doi/pdf/10.3141/1559-09>, 1996.

The Marine base at Camp Pendleton has located all of its built facilities a substantial distance away from S.O.N.G.S., as well as the access points. Except for operations of an unknown nature near the coast, there is no evidence that Camp Pendleton operations would be significantly affected by an accident in the small-scale scenario examined.

### Impacts to 10-mile and 50-mile radii

In this case, we are interested in the overall economic activity within individual ZIP codes that fall within the 10- and 50-mile radii of the S.O.N.G.S. facility. We consider this the economic impact of a mass evacuation. IMPLAN provides the total Gross Regional Product for the affected area, total employment, and total personal income for each ZIP code that we identified to fall in the 10- and 50-mile radii. These are aggregated to create the single-year impact of an evacuation, as shown in Table 4 and Table 5 below. The 50-year estimate is a simple present value calculation using the Office of Management and Budget's 30-year nominal interest rate of 2.8%.<sup>22</sup>

For the scenario of an accident with an impact zone of 10 miles shown in Table 5, the loss in GRP would be \$6.2 billion and the loss of 53,000 jobs. If the zone was evacuated for 50 years, the net present value of the economic loss would be \$166.3 billion.

**Table 5. IMPLAN Results – 10 Mile Radius (\$ Billions)**

Period	Gross Regional Product	Total Personal Income	Total Employment
<b>1 Year</b>	\$6.2	\$7.7	53,000
<b>50 Years</b>	\$166.3	\$205.5	-

For the accident scenario with a wide area of contamination out to 50 miles, as shown in Table 6, the GRP loss increases to \$500 billion. That equals 2.6% of the U.S. Gross Domestic Product or 18.2% of California's Gross State Product for 2017.<sup>23</sup> Lost employment would amount to 4.5

<sup>22</sup> Circular A-94 Appendix C Revised November 2016. Office of Management and Budget. <https://www.whitehouse.gov/wp-content/uploads/2017/11/Circular-094C.pdf>

<sup>23</sup> U.S. Bureau of Economic Analysis, "Regional Data: GDP & Personal Income Mapping," [https://apps.bea.gov/iTable/iTable.cfm?reqid=99&step=1#tabpanel\\_1\\_2](https://apps.bea.gov/iTable/iTable.cfm?reqid=99&step=1#tabpanel_1_2), retrieved October 2018.

million jobs or more than 20% of present California employment.<sup>24</sup> The net present value loss of \$13.4 trillion over 50 years is equivalent to 70% of U.S. GDP in 2017.

**Table 6. IMPLAN Results—50 Mile Radius (\$ Billions)**

Period	Gross Regional Product	Total Personal Income	Total Employment
<b>1 Year</b>	\$500.6	\$383.9	4,500,000 <sup>25</sup>
<b>50 Years</b>	\$13,400.0	\$10,300.0	-

## Summary

Results for the one-mile, 10-mile, and 50-mile radii are presented below in three tables by impact scenario for a single year and for a 50-year duration. For the one-mile radius, we consider only disruption of the I-5 transportation corridor for a year due to the isolated location of the site, as shown in Table 7. Potential impacts range from \$266 million for the one-mile event to \$500 billion in a single year for an event extending out to 50 miles.

**Table 7. Summary of Results – 1 Mile Evacuation Radius (\$ Billions)**

	Transportation Disruption
<b>1 Year</b>	\$0.266

The 10-mile and 50-mile (Table 8) radii impacts includes real estate asset value loss, as well as IMPLAN results for the gross regional product measure of annual economic activity. Residential

<sup>24</sup> California Employment Development Department, “California Profile,” <https://www.labormarketinfo.edd.ca.gov/cgi/databrowsing/localAreaProfileOSResults.asp?selectedarea=California&selectedindex=0&menuChoice=localAreaPro&state=true&geogArea=0601000000>, retrieved October 2018.

<sup>25</sup> San Diego and Orange counties have slightly more than 3 million employed workers. The additional 1.5 million arise from the high concentration of industries in south Los Angeles County, and the extended multiplier effect of closing both the Ports of Los Angeles and Long Beach and nearby large petroleum refineries that supply much of the Western U.S.

property losses could range from \$11 billion to \$500 billion depending on the evacuation scenario, and the loss in annual gross regional product could range from \$6 billion to \$500 billion. In the 50-mile impact scenario, up to \$13.4 trillion could be at risk over a 50-year time horizon.

**Table 8. Summary of Results – 10-mile radius (\$ Billions)**

Period	Real Estate Assets	Gross Regional Product
<b>1 year</b>	-	\$6.2
<b>50 years</b>	\$11.2	\$166.3

**Table 9. Summary of Results – 50-mile radius (\$ Billions)**

Period	Real Estate Assets	Gross Regional Product
<b>1 year</b>	-	\$500.6
<b>50 years</b>	\$503.4	\$13,400.0

This analysis ignores the likely multiplier effects to the rest of the state and nation, particularly related to the potential extended closure of the busiest ports on the West Coast.<sup>26</sup>

The size of this risk exposure contrasts with the insurance coverage provided to nuclear reactors under the federal Price-Anderson Act. That federal law administered by the NRC offers \$450 million per reactor.<sup>27</sup> A second self-insurance pool across all reactors adds another \$13

<sup>26</sup> Analysis of these impacts was beyond the scope of this study due to the large scale and complexity of such an analysis that would require substantially more resources.

<sup>27</sup> NRC, "Increase in the Maximum Amount of Primary Nuclear Liability Insurance," *Federal Register*, <https://www.federalregister.gov/documents/2016/12/30/2016-31368/increase-in-the-maximum-amount-of-primary-nuclear-liability-insurance>, December 30, 2016.



billion.<sup>28</sup> For S.O.N.G.S., this would amount to \$13.4 billion, or just 8% of the projected losses in economic activity as measured by the gross regional product for an event impacting a 10-mile radius over 50 years, and 0.1% for a 50-mile event. Similarly, it would cover only 12% of residential real estate asset losses for a 10-mile event, and less than 3% for a 50-mile event.

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<sup>28</sup> <https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/nuclear-insurance.html>

## Appendix A: Understanding IMPLAN Data

The tool used to estimate the relative size of different economic sectors within the study area for this baseline report was the IMPLAN regional economic model.<sup>29</sup>

IMPLAN is a widely-accepted economic analysis tool used to value economic sectors. Input-output models such as IMPLAN use area-specific data on industrial and commercial activity to trace how a dollar of investment moves through a regional economy. These models are commonly used to evaluate economic activity in which changes in the total demand for output of the industries being studied results in changes in inputs and outputs by the local economic sectors. For example, these models have been used to estimate the impacts of such projects as construction and operation of new factories, development of tourism facilities, and military base closures. A recent study by the University of California found that IMPLAN produced an accurate estimate of actual job losses in the Central Valley related to the 2009 drought.<sup>30</sup>

IMPLAN draws from economic census data to compile county-level wage and salary information at the four-digit standard industrial code level. National data is adjusted for the subject region's industrial and trading patterns. Based on this structure, IMPLAN estimates the regional economic impact that would result from a dollar change in the output of local industries delivered to final demand (i.e., to ultimate purchasers, such as consumers outside the region).

More specifically, IMPLAN data provides estimated industry output, wage income, proprietary income, other property income, indirect business taxes, value added, and employment for 440 individual economic sectors.<sup>31</sup> IMPLAN sectoring is based on the North American Industrial Classification System (NAICS) and the individual sectors can be aggregated to the 2-digit and 3-digit NAICS level. Each measure of economic activity contained in the IMPLAN data set is defined as follows:

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<sup>29</sup> See <https://implan.com/>

<sup>30</sup> Howitt, Richard E., Duncan MacEwan, and Josué Medellín-Azuara. 2011. "Drought, Jobs, and Controversy: Revisiting 2009." *Agricultural and Resource Economics Update*, V. 14 no. 6, Jul/Aug.

<sup>31</sup> Depending on the region in question, some sectors will show no economic activity. For example, IMPLAN sector 7 – Tobacco Farming – shows no economic activity for most regions outside of the southern United States.

**Asset Value** is composed of the stream of annual economic activities that create the value embedded in the asset. For residential real estate, it is the income that could be generated from renting the asset to a resident, or conversely, the avoided rental payments over a 30 year or longer period. Thus, the loss in real estate asset value is most comparable to the 50-year losses in economic activity presented here. However, since the real estate asset value is comprised of the flow of annual economic activities captured in the IMPLAN results, the real estate asset value is implicitly included in the 50-year scenarios, and should not be added.

**Employment** is reported as a single number of jobs (part- and full-time) for each industry. This differs from the full-time equivalent (FTE) measure often reported that adjusts total jobs for the number of hours worked per week (typically 40 hours). The number of jobs reported in IMPLAN typically will not match the number of employed individuals, as some individuals will hold multiple jobs, and some jobs will have multiple people employed over the year. Nevertheless, the IMPLAN value is a close approximation of total employment.

**Gross Regional Product (GRP)** as an equivalent measure to **value added** which equals the sum of wage income, proprietor income, other property income, and indirect business taxes. It is akin to measures of gross domestic product (GDP), in that it indicates the portion of regional output generated by economic activity occurring *within* the region in question. It is the economic value *added* to the production process beyond purchased inputs such as raw materials, energy or labor from outside the region.

**Industry or Economic Output** represents the value of an industry's total production, including both value-added and purchased inputs. The IMPLAN data are derived from a number of sources, including U.S. Bureau of Census economic censuses, U.S. Bureau of Economic Analysis output estimates, and the U.S. Bureau of Labor Statistics employment projections. These are aggregated up to estimate the total regional output.

**Other Property Income** consists of payments for rents, royalties, and dividends. Payments to individuals in the form of rents received on property, royalties from contracts, and dividends paid by corporations are included here as well as corporate profits earned by corporations. The IMPLAN estimates of other property income are derived from U.S. Bureau of Economic Analysis Gross State Product data.

**Personal Income** is the measure of total household income in a region. It includes all sources of income, not just direct monetary income, such as salaries, wages, self-employment, retirement and interest, which is the metric reported by the U.S. Census Bureau.<sup>32</sup> The additional categories included in personal income are equity and asset returns. In regions with greater income asset holdings, such as wealthier and older communities, the average personal income can diverge significantly from the standard federal measure of household income for this reason.

We report many of the most salient measures from the IMPLAN and other data sets in this impact analysis for reference. IMPLAN is used as the primary data set since IMPLAN will be used to assess any potential impacts. The other data is used to calibrate and reconcile the IMPLAN data where needed.

**Proprietary Income** consists of payments received by self-employed individuals as income. Any income received for payment of self-employed work, as reported on Federal tax forms, is counted as proprietary income. This includes income received by private business owners, doctors, lawyers, and the like.

**Taxes on Production & Imports** consist of sales and excise taxes, customs duties, property taxes, motor vehicle licenses, severance taxes, other taxes, and special assessments. These taxes do not include nontax payments and subsidies. IMPLAN estimates of indirect business taxes are derived from U.S. Bureau of Economic Analysis data.

**Wage Income** describes the total payroll costs (including benefits) of each industry in a region. It includes the wages and salaries of workers who are paid by employers, as well as benefits such as health and life insurance, retirement payments, and non-cash compensation.

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<sup>32</sup> See

<https://implanhelp.zendesk.com/hc/en-us/articles/115009505867-Why-is-Personal-Income-for-My-Region-so-High>