CALIFORNIA ENERGY COMMISSION

CALIFORNIA NATURAL RESOURCES AGENCY

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Waste Management Davis Street Resource Recovery Complex LNG/LCNG Station Project (Phase I)

Private-access CNG fueling station in San Leandro, California

Prepared for: California Energy Commission

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PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued PON-12-605 to provide funding opportunities for projects that develop infrastructure necessary to store, distribute, and dispense electricity, E-85, propane, diesel substitutes, and natural gas. In response to PON-12-605, the recipient submitted an application which was proposed for funding in the CEC's notice of proposed awards March 18, 2013 and the agreement was executed as ARV-13-003 on January 7, 2014.

ABSTRACT

Waste Management of Alameda County, Inc. sought to develop a liquefied natural gas and liquefied compressed natural gas fueling station to support its existing and rapidly expanding private fleet of compressed natural gas-powered solid waste collection and waste transfer vehicles in Alameda County. This critical infrastructure project provides solutions to overcome the significant refueling barrier that has hindered the development and widespread use of natural gas as a transportation fuel in the Bay Area.

The project site, located at Waste Management of Alameda County's Davis Street Resource Recovery Complex at 2615 Davis Street in the city of San Leandro, California, provides a convenient and affordable source of liquefied natural gas and liquefied compressed natural gas for the Waste Management of Alameda County fleet of transfer tractors that fuel at the facility daily.

The goal of developing a liquefied natural gas and liquefied compressed natural gas fueling station in the San Leandro area along several important local and regional transportation corridors, including United States Interstate 880, Interstate 580, and Interstate 238, was to provide incentive for foods movement operators, municipal fleets, school districts, and water agencies to adopt or expand the use of their natural gas advanced technologies. Another goal was to enable the accelerated replacement of heavy-duty diesel trucks with clean-burning, ultra-low-emission natural gas trucks to stimulate the United States manufacturing base and economy, and assist in the development of a more aggressive "green" automotive industry in the United States. A final goal of this project was to infuse further the Northern California regional natural gas refueling infrastructure with locally produced, ultra-low carbon liquefied natural gas and liquefied compressed natural gas.

Keywords: Compressed natural gas, liquefied natural gas, liquified compressed natural gas, fueling station, Waste Management of Alameda County

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EXECUTIVE SUMMARY

Waste Management of Alameda County, Inc. secured grant support from the CEC for $568,150 to develop a liquefied natural gas and liquefied compressed natural gas fueling station. The overlying goal of the project was to support Waste Management of Alameda County's existing and rapidly expanding private fleet of liquefied natural gas and liquefied compressed natural gas-powered transfer tractors in San Leandro along several important local and regional transportation corridors, including United States Interstate 880, Interstate 580, and Interstate 238. The total budget for the project was $1,420,375 of which Waste Management of Alameda County provided 60 percent cost-share equal to $852,225. Waste Management of Alameda County now owns and operates a fast-fill liquefied natural gas and liquefied compressed natural gas fueling station at its Davis Street Resource Recovery Complex in Alameda County. At the station, Waste Management of Alameda County fuels a fleet of 40 dedicated transfer tractors.

Waste Management of Alameda County's contractor, ET Environmental, was responsible for the construction of the compressed natural gas fueling station, which became operational in June 2015. Waste Management of Alameda County's objective in constructing this station is to provide the additional necessary infrastructure needed in order to make alternative fuels like natural gas a commercially available and preferable fueling option. Natural gas contains less carbon than any other fossil fuel, and thus produces lower carbon dioxide and greenhouse gas emissions per year. In fact, natural gas vehicles produce up to 20-30 percent fewer greenhouse gas emissions than comparable diesel vehicles. Natural gas is typically less expensive than diesel, costing less per unit of energy. Waste Management of Alameda County is quite familiar with the many benefits of natural gas, and therefore sought to provide these benefits to its own fleet and others in the development of this station.

Engineering and preconstruction designs were completed as outlined in the original schedule by July of 2014. Permits were finalized in November, and construction of the station commenced in December of 2014. The station became operational in June of 2015, and it has been operating successfully since. As a result of this project, over 600,000 diesel gallon equivalents are replaced annually, yielding a reduction in over 48 tons of nitrogen oxides and 0.98 tons of particulate matter.

CHAPTER 1: Project Background and Objectives

Project Background

A primary barrier to natural gas vehicle deployment is the lack of supporting infrastructure. There is limited access to natural gas infrastructure in San Leandro around the heavily trafficked areas of the Oakland International Airport and Interstate 880 and Interstate 580 nearby. Limited access deters the adoption and expansion of natural gas technologies, and additionally the high costs of upgrading and constructing natural gas infrastructure is prohibitive.

Waste Management of Alameda County, Inc. (WMAC) sought to develop a liquefied natural gas (LNG) and liquefied compressed natural gas (LCNG) fueling station to support its existing and rapidly expanding fleet of compressed natural gas (CNG)-powered waste transfer tractors in Alameda County. The completed LNG/LCNG station is located at 2615 Davis Street in the City of San Leandro, providing a convenient and affordable source of natural gas fuel for WMAC's expanding fleet of solid waste transfer tractors that fuel at the facility daily. There was a critical gap in fueling infrastructure and not enough convenient fueling to support WMAC's planned deployment of CNG vehicles. WMAC has an LCNG station at its 98th Avenue location to support its large fleet of solid waste collection vehicles which provided the ability to fuel the initial deployment of the CNG transfer tractor, however there was insufficient capacity to fuel WMAC's planned fleet on an ongoing basis.

For this project, the CEC awarded WMAC a grant totaling $568,150, which WMAC matched with $852,225 of private funds.

Project Objectives

The objectives of developing the Davis St. LNG/LCNG station were to support fuel requirements of the existing and planned expansion of WMAC's CNG refuse collection and transfer trucks, along with other fleets in the region. Another objective of the project was to reduce greenhouse gases (GHG) from transportation activities in California.

At the time the grant application was prepared, WMAC's goals of this project included the following:

- Provide for the annual station throughput and corresponding displacement of more than 958,090 gallons of diesel fuel with domestically produced, low-carbon natural gas in the station's first year of operation;
- Provide for the annual station throughput and corresponding displacement of more than 1,537,401 gallons of diesel fuel at full build-out of the Davis Street Resource Recovery Complex natural gas fleet by 2020;
- Promote regional growth in LNG and CNG vehicle deployments and the replacement of heavy-duty diesel trucks by filling a critical gap in Bay Area infrastructure;
- Provide for the annual reduction of more than 3,441 metric tons of GHG in the station's first year of operation;

- Provide for the annual reduction of 5,522 metric tons of GHG, more than 120 tons of nitrogen oxides ($NO_{x)}$, and 2.2 tons of particulate matter (PM) at full build-out of the Davis Street Resource Recovery Complex natural gas fleet by 2020;
- Demonstrate the commercial potential for WMAC's vehicle to use renewable natural gas from the High Mountain Fuels plant;
- Complete these goals at a total cost-effectiveness as low as $0.0763 per gallon of diesel fuel displaced and $21.26 per metric ton of GHG reduced over the project life through 2020; and,
- Serve as a model for other large-scale refuse collection and station operators to successfully implement advanced technology infrastructure programs in collaboration with state agencies.

CHAPTER 2: Scope of Work

Scope of Work

WMAC's scope of work under agreement ARV-13-003 included the installation, operation, and reporting of the LNG/LCNG fueling station. WMAC was responsible for constructing the LNG/LCNG fueling station with new equipment:

- 18,000 Gallon Short Tank
- Double LCNG Pump Skid
- Two (2) LNG Dispensers
- Two (2) CNG Dispensers
- CNG Storage Bottles

All equipment meets all American Petroleum Institute, American Society of Mechanical Engineers, International Society of Automation, American Gas Association, National Electric Code, and National Fire Protection Association requirements. The station also included the installation of utility tie-ins, start-up, debugging, stabilizing the refueling station, along with design, engineering, permitting, project management, and purchasing. WMAC's work included fire protection, fire detection, methane detection, and all necessary safety elements identified with hazardous operations process safety.

Technical Tasks

WMAC completed several technical tasks in order to complete the LNG/LCNG station development in an orderly and efficient manner. WMAC completed the below technical tasks under this project.

Engineering and Preconstruction

WMAC performed civil and architectural engineering, including design management services and preconstruction planning. WMAC finalized the station layout, engineering and design. WMAC provided design management services and preconstruction planning services and submitted the final station design to the Commission Agreement Manager. WMAC experienced some delays coordinating with the permitting authorities and utilities, but was otherwise on track, and within the planned budget for this project. Engineering and preconstruction for the station was completed on July 18, 2014.

LNG/LCNG Equipment Procurement

WMAC ordered, took delivery of, and installed all necessary equipment and supplies at the site. The installation of equipment, controls, and support infrastructure were completed in accordance with the system design specifications. LNG/LCNG Equipment Procurement was completed by January 31, 2015.

Site Work, Civil Improvements, and Equipment Installation

WMAC performed construction activities at the site in accordance with the design specifications to prepare for the arrival of the equipment. WMAC oversaw and managed site construction and electrical, mechanical, and civil improvements. WMAC's contractor ET Environmental had

the site and foundation prepared by March 2015. Site work and civil improvements were complete by April 2015, and equipment installation was completed on June 17, 2015.

Station Start-Up and Commissioning

WMAC completed the major construction of the LCNG station in June 2015. The final building inspection was completed on June 17, 2015 and the final commissioning and commencement of operations began on June 18, 2015. WMAC conducted the final fire signoff on June 19, 2015 and the station has been operational since.

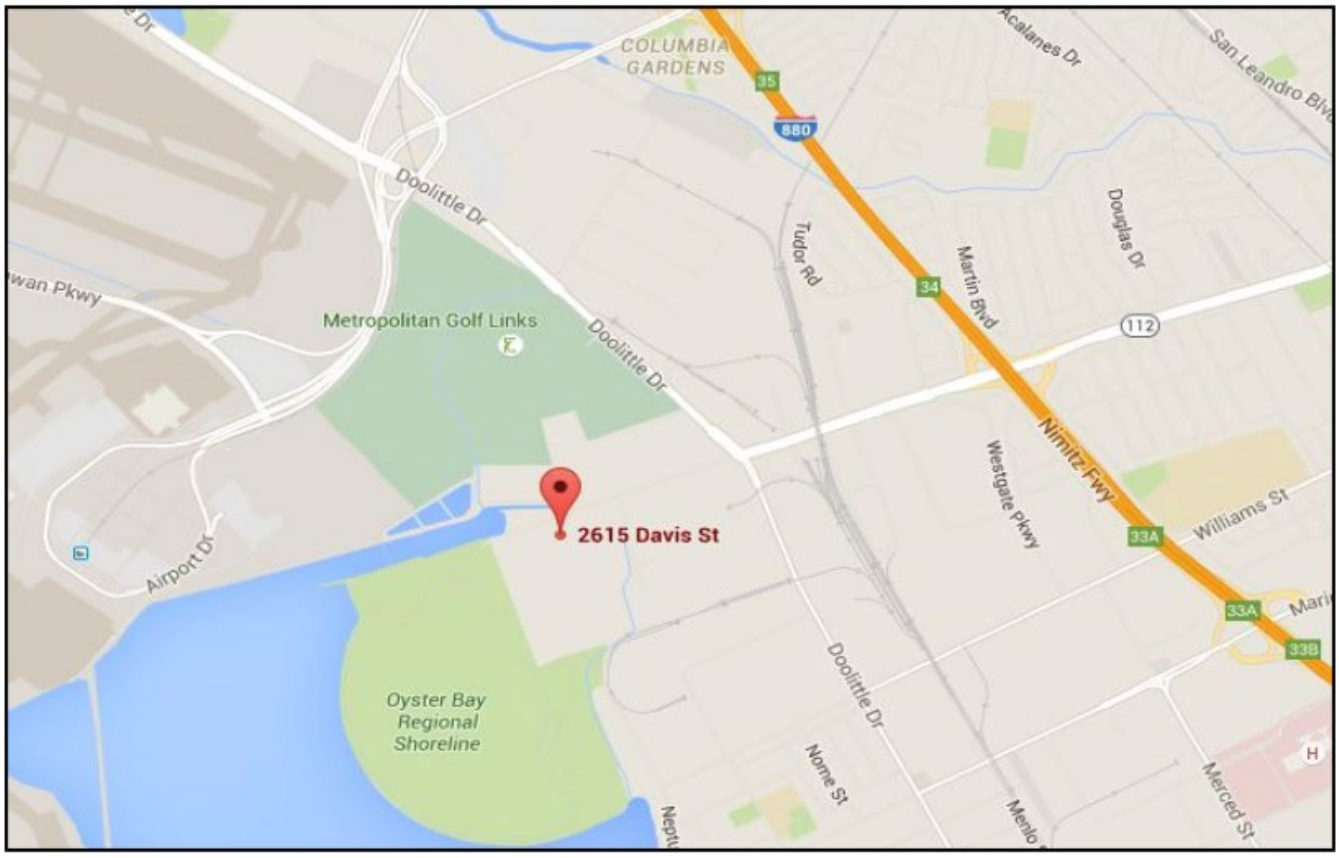
Data Collection and Analysis

WMAC collected and continues to collect operational data from the station. WMAC analyzes this data for the economic and environmental benefits of the project, such as station throughput and associated project emission benefits. In the application, WMAC anticipated having a fleet of 43 vehicles operating out of this location. As of February 2017, approximately 40 WMAC trucks utilize the Davis Street CNG Station; therefore, the target annual throughput of 958,090 diesel gallon equivalents (DGE) was not realized during the first year of operations (actual was 617,148 DGE). WMAC vehicles operating in this area also utilize the Altamont fueling station, which further reduces the throughput numbers at the Davis Street location. WMAC specifically requested CEC support for the Phase I efforts to install private fueling at the Davis Street site. At this point in time, the implementation of public access fueling as a separate project is still a potential enhancement to the existing private fueling facility, but no decision has been made regarding public access fueling.

Site Location

Figure 1 shows the location of the LNG/LCNG station relative to the surrounding region.

Figure 1: LNG/LCNG Station Location: 2615 Davis Street, San Leandro, CA 94577



Source: Waste Management of Alameda County

Photographs

Figure 2 and Figure 3 show the West and East side of the LNG/LCNG compound, respectively.

Figure 2: West Side of Compound

Source: Waste Management of Alameda County

Figure 3: East Side of Compound

Source: Waste Management of Alameda County

Annual Fuel Throughput

During the Phase I of this project, the station is only available to privately operated WMAC vehicles. Public access fueling is still under consideration as a second phase of the project. Approximately 40 WMAC units currently utilize the Davis St. LNG/LCNG station. The station has been operational since June 2015. The station completes an average of 26 fleet transactions per day. As shown in Table 1, the fuel usage over the twelve-month data collection period, July 2015 – July 2016, was approximately 617,148 DGE. On average, monthly throughput is approximately 47,473 DGE.

Table 1: Davis St. LNG/LCNG Station Fuel Throughput

Month	Total Site Throughput GGE	Total Site Throughput DGE
15-Jul	64568.00	55944.51
15-Aug	11198.00	9702.43
15-Sep	62607.00	54245.41
15-Oct	68204.00	59094.89
15-Nov	53815.00	46627.64
15-Dec	60518.00	52435.41
16-Jan	62677.00	54306.06
16-Feb	56016.00	48534.68
16-Mar	50160.00	43460.79
16-Apr	55227.00	47851.06
16-May	54171.00	46936.10
16-Jun	55389.00	47991.42
16-Jul	57727.00	50017.17
Total Throughput for Reporting Period	712277.00	617147.58
Monthly Average	54790.54	47472.89

Source: Waste Management of Alameda County

Emission Reductions

The average annual throughput of the Davis St. LNG/LCNG station was 617,148 DGE, which yields significant emission reduction benefits. Using the Carl Moyer Program Guidelines[1] methodology (Adopted April 2011) and a 2006 diesel refuse collection vehicle baseline model year, WMAC was able to calculate the criteria pollutant emission reductions shown in Table 2. WMAC is able to achieve the reduction of 48 tons per year of NO_x, and 0.98 tons per year of particulate matter (PM). Additionally, the project will contribute to the reduction of 2,217 metric tons of carbon dioxide equivalent GHG emissions per year, according to the General Formula for Calculating Annual Carbon Displacement, shown in Figure 4. GHGs were calculated according to fuel consumption, using emission factors from the Low Carbon Fuel Standard Carbon Intensity Lookup Table for Diesel and Fuels that Substitute for Diesel[2].

Table 2: Emission Reduction Calculation

Criteria Pollutant Emission Reduction Calculation	**NO_x**	**PM**
Baseline Emission Factor (g/mi) 2006 Diesel	11.64	0.254
Baseline Emission Factor (g/mi) 2006 Diesel, w/o PM Retrofit	11.64	0.254
Reduced Emission Factor (g/bhp-hr)	.20	0.01
Conversion Factor (bhp-hr/mi)	2.90	2.90
Energy Consumption Factor (bhp-hr/gal)	18.50	18.50
Twelve (12) Month Fuel Consumption	617,148	617,148
Percent in Operation in CA (1.0 = 100%)	1.0	1.0
Ton/907,200 g	0.0000011	0.0000011
Projected Baseline Emissions (tons/year)	50.514	1.102
Projected Reduced Emissions (tons/year)	2.52	0.125
Annual Emission Reductions (tons/year)	47.997	0.976
Emission Weighting for Cost Effectiveness Calculations	1.00	1.00
Weighted Emission Reductions	48.00	0.98

Source: Waste Management of Alameda County

1 California Environmental Protection Agency, Air Resources Board, "Carl Moyer Program Guidelines" June 2011 https://ww2.arb.ca.gov/guidelines-carl-moyer

2 California Environmental Protection Agency, Air Resources Board, "Carbon Intensity Lookup Table for Gasoline and Fuels that Substitute for Diesel" December 2012 https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities

Figure 4: General Formula for Calculating Annual Carbon Displacement:

$$Annual\ Carbon\ Displacement = \left(\frac{gCO_2e}{MJ}_{(r)} - \frac{gCO_2e}{MJ}_{(b)}\right) x \frac{MJ}{dge}\ x \frac{dge}{yr}\ x\ [unitless]\ x\ \frac{MT}{g} = \frac{MTCO_2e}{yr}$$

r = reference fuel
b = biofuel

$$\left(\frac{94.71gCO_2e}{MJ}_{(r)} - \frac{68gCO_2e}{MJ}_{(p)}\right) x \frac{134.47MJ}{dge}\ x \frac{617{,}148.58dge}{yr}\ x\ 1\ x\ \frac{MT}{1{,}000{,}000g} = \frac{2{,}217MTCO_2e}{yr}$$

Source: Carl Moyer Program Guidelines

CHAPTER 3: Results

Results

Table 3 summarizes the data collected during the first year of operations. Approximately 40 vehicles utilized the station, and on average 26 of those vehicles refueled at the station daily (26 fueling events). WMAC has not hit the maximum capacity of the new fueling system, which is 60,480 gallons LNG/day. All transactions at the station were from WMAC.

The station is integral to WMAC operations; each transfer truck has a duty cycle of 8.9 hours on average per day, covering over 250 miles daily.

Table 3: Data Collection for WMAC Davis Street Station (July 2015 – July 2016)

Data Type	Data
Comparison of public vs. fleet transactions per day	0 public vs. 26 fleet
Comparison of public vs. fleet consumption per day in GGE	0 public vs. 2205.6 fleet
Number of days or hours per month per year that each station was inoperative	172.5 hours (average of 14.375 hours/month)
Maximum capacity of new fueling system	60,480 gallons LNG/day
Electricity required to power CNG compression equipment	240 kilowatt daily average (6,120 kilowatt daily maximum)
Duty cycle of the current fleet and the expected duty cycle of future vehicle acquisitions	Avg. hours per day: 8.9 Avg. miles per day: 269.4 Avg. days per week: 6 Avg. loads per day: 4
Identify any current and planned use of renewable energy at the facility	None.
Describe any energy efficiency measures used in the facility that may exceed Title 24 standards in Part 6 of the CA. Code of Regulations	No energy savings measures that exceed Title 24 standards.

Source: Waste Management of Alameda County

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC)—The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

1. Forecasting future statewide energy needs
2. Licensing power plants sufficient to meet those needs
3. Promoting energy conservation and efficiency measures
4. Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
5. Planning for and directing state response to energy emergencies.

COMPRESSED NATURAL GAS (CNG)—Natural gas that has been compressed under high pressure, typically between 2,000 and 3,600 pounds per square inch, held in a container. The gas expands when released for use as a fuel.

DIESEL GALLON EQUIVALENT (DGE)—The amount of alternative fuel it takes to equal the energy content of one liquid gallon of diesel gasoline.

GASOLINE GALLON EQUIVALENT (GGE)—The amount of alternative fuel it takes to equal the energy content of one liquid gallon of gasoline. GGE allows consumers to compare the energy content of competing fuels against a commonly known fuel—gasoline. GGE also compares gasoline to fuels sold as a gas (natural gas, propane, and hydrogen) and electricity.

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (NOx), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

LIQUID COMPRESSED NATURAL GAS (LCNG)—The volume of liquefied compressed natural gas is only around 1/600th of the volume of gaseous natural gas. This results in significant advantages where gas transportation is concerned in particular. Following liquefaction and transportation, the liquefied natural gas (LNG) is regasified (converted into CNG) with subsequent forwarding to grid gas companies via pipelines.

LIQUEFIED NATURAL GAS (LNG)—Natural gas that has been condensed to a liquid, typically by cryogenically cooling the gas to minus 260 degrees Fahrenheit (below zero).

NITROGEN OXIDES (OXIDES OF NITROGEN, NOx)—A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes and are major contributors to smog formation and acid deposition. NO2 is a criteria air pollutant and may result in numerous adverse health effects.

PARTICULATE MATTER (PM)—Unburned fuel particles that form smoke or soot and stick to lung tissue when inhaled. A chief component of exhaust emissions from heavy-duty diesel engines.

WASTE MANAGEMENT OF ALAMEDA COUNTY, INC. (WMAC)- Waste Management of Alameda County, Inc. We provide garbage, recycling and composting services for homes and businesses throughout the Bay Area.[3]

[3] Waste Management of Alameda County, Inc. https://www.wm.com/location/california/bay_area/index.jsp