

# Knob Hill – South Beatrice and Clay Center Junction – Greenleaf Transmission Line Study Final Report

SPP Engineering Department, Planning Section

PUBLISHED: September 2008

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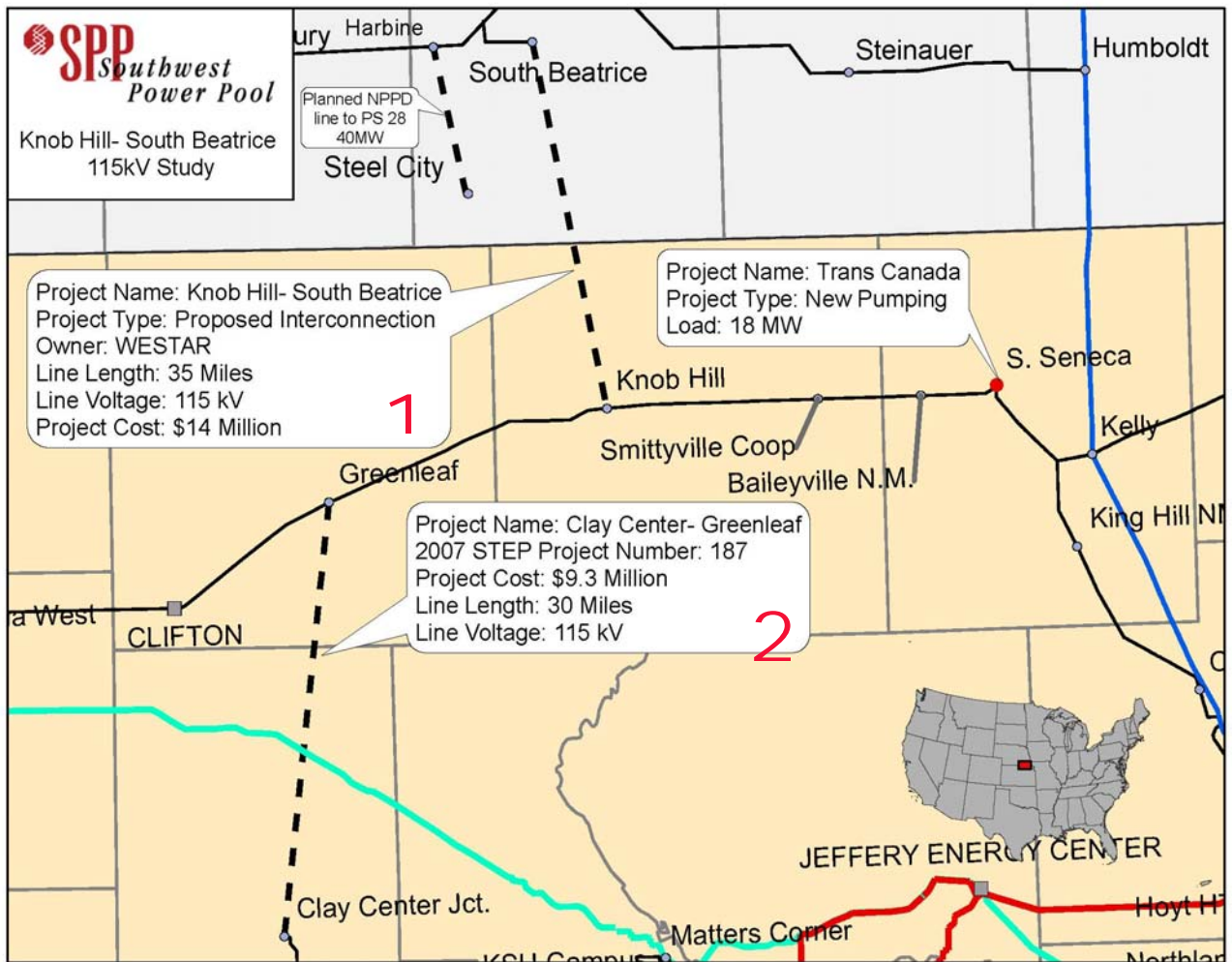
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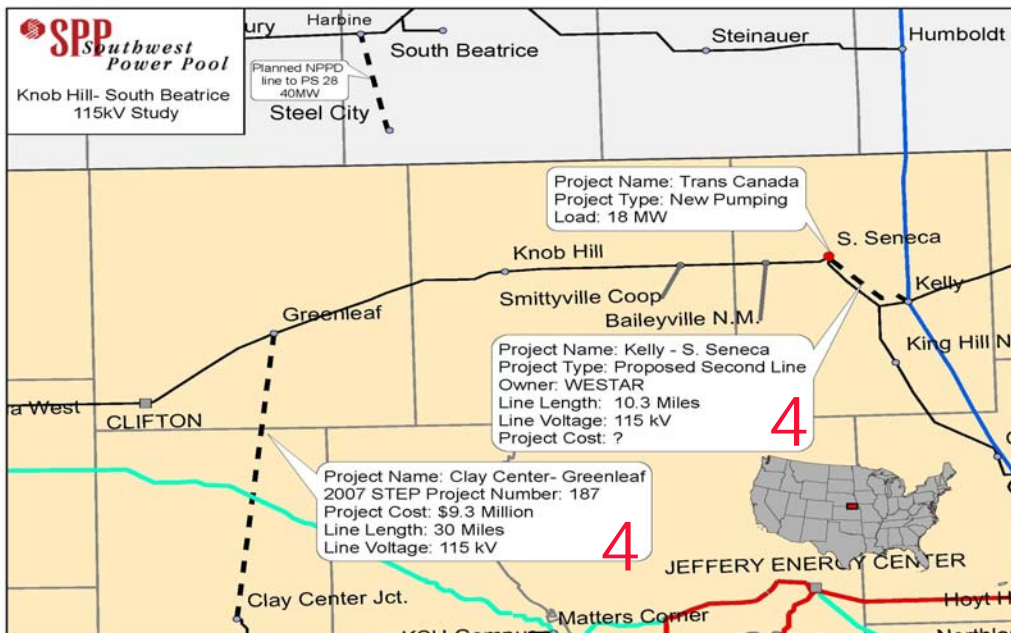
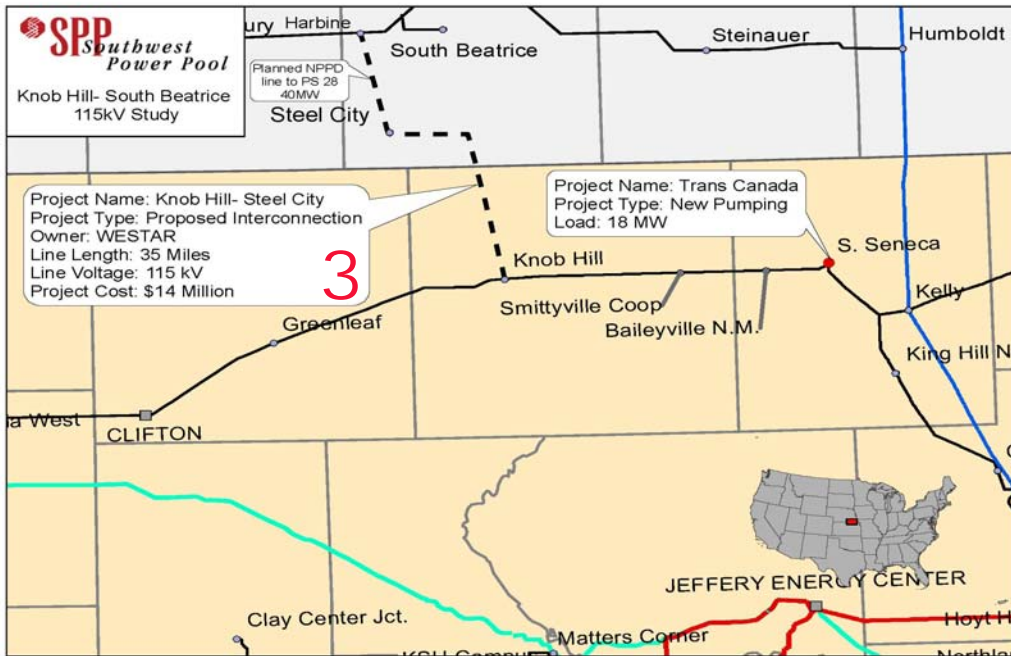
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## EXECUTIVE SUMMARY

The objective of this study is to analyze the relative merits of four proposed transmission lines. Westar is proposing a new tie line between Westar and Nebraska Public Power District (NPPD). That would be an 115kV line from Westar’s Knob Hill to either the NPPD’s South Beatrice substation or to the NEW Steele City, NE pumping station. A similar 115kV line was previously proposed to be built from Clay Center Junction to Greenleaf. All proposed lines are intended to solve similar voltage and thermal problems along the 115kV line from Concordia to Kelly.

The general area studied is shown in the maps below:





**Study Area**

The recently obtained data for the TransCanada Phase 2 pipe line project posed an additional concern about the group of loads expected to be added in this region in the near future. These loads are several large pump stations for the TransCanada Pipeline. The loads were added to the models so that their impact would be included in the resulting recommendation.

Four sets of models were created. The first included the Knob Hill – South Beatrice 115kV line. The second included the Clay Center-Greenleaf 115 kV line. The third included the Knob Hill – Steele City 115 kV line. The fourth included the Clay Center Junction – Greenleaf 115kV and an additional Kelly-Seneca 115 kV circuit. AC Contingency Analysis was performed on each set. Then, the results were compared to each other.

The results show that the addition of the Knob Hill – Steele City and a re-conductoring of the Kelly-Seneca 115kV line does provide the best regional solution and is therefore the recommended alternative.

## **INTRODUCTION**

### **Background**

The TransCanada Keystone Pipeline project intends to build several new pump stations; each has a load of 18 mw, throughout Nebraska, Kansas, Oklahoma and Missouri. Three of these new pump stations are in Northeast Kansas. Westar conducted a study to evaluate the impact of these large pump stations on their transmission system. Westar’s study concluded that the new loads would require the addition of a new line in the area and their study proposes a new Knob Hill to South Beatrice 115kV line to meet this need. This line is estimated to be about 35 miles long and would have a summer rating of 223/245MVA.

Prior to Westar’s proposal, the Southwest Power Pool’s Board of Directors approved a project to build a new 115kV transmission line from Clay Center Junction to Greenleaf. This was Project ID #187 of the 2007 SPP Transmission Expansion Plan (STEP). It is estimated to be about 30 miles long and would have a summer rating of 120/130MVA. After discussions with Westar and OMPA staff it was decided to reevaluate the four projects on their respective benefits and drawbacks. Therefore this SPP study was conducted to determine which project provides the best regional solution.

## **STUDY METHODOLOGY**

### **SCOPE**

This study was performed according to the Study Scope. The Study Scope outlined the methods for creating the load flow models and for performing the reliability analysis. For convenience, a copy of the Study Scope is included below:

- **Model Assumptions**
  - Use 2007 SPP Transmission Expansion Plan (STEP) models

- Version “R3” without STEP upgrades to allow for reevaluation of upgrades proposed in 2007 STEP
- All seasons (2008 April Minimum – 2017 Summer Peak)
- All base and transactional scenarios (0-5)
- Total of 66 models
- Add Westar’s anticipated loads for TransCanada Keystone Pipeline
  - Pump Station 29 = 18 + j8.6 MVA at S. Seneca 115kV
  - Pump Station 30 = 18 + j8.6 MVA at Walnut 115kV
- Remove Westar monthly service which was erroneously included in the original MDWG models
- All dispatch adjustments will follow SPP tariff studies merit order
- **Reliability Analysis**
  - AC contingency analysis (N-1) on all load flow models using PSS/E
  - Contingencies
    - Single element (N-1) outages of:
      - SPP facilities 69kV and above
      - SPP generators
      - NPPD, OPD and LES facilities 69 kV and above
      - Entergy and AECI facilities 100kV and above
      - First tier companies 230kV and above
    - Multi-terminal outages as provided for the 2007 STEP by SPP members and first tier companies
  - Monitored Elements
    - SPP facilities 69kV and above (overload & voltage)
    - NPPD, OPD and LES facilities 69kV and above (overload & voltage)
    - Entergy and AECI facilities 100kV and above (overload)
    - First tier companies 230kV and above (overload)
  - Apply SPP and NERC reliability standards

## Model Assumptions

This study used the 2007 SPP Transmission Expansion Plan (STEP) models without the STEP upgrades included to allow for reevaluation of the two upgrades. All seasons and all transactional scenarios were used. The new TransCanada Pipeline pump station loads were added to the models as provided by Westar. To feed these loads, generation within Westar was dispatched according to merit order. In 2012 and 2017 Summer Peak seasons, additional power from IPP plants throughout SPP is used to supplement Westar generation.

The Knob Hill – South Beatrice 115kV line was added to the first set of models. The Clay Center Junction – Greenleaf 115kV line was added to a second set of models. The Knob Hill – Steele City

line was added to the third set of models. The Clay Center – Greenleaf and a second circuit, Kelly-Seneca, was added to the fourth set of models.

## Reliability Analysis

The reliability analysis was performed on the load flow models using PSS/E’s AC contingency analysis (N-1) software. All contingencies 69kV and above were taken in SPP, NPPD, OPPD, and LES. All overload and voltage violations were then reported for these same areas.

The reported violations from the Knob Hill – South Beatrice model were then compared to violations from the other three 115 kV proposals. The differences can be attributed directly to one line or the other. This data was annotated to describe which upgrades are associated with each violation and to describe whether that upgrade needs to be moved forward or backward in time.

## RESULTS OF ANALYSIS

### Knob Hill – South Beatrice 115kV

The results show that the Knob Hill – Beatrice 115kV line, along with the re-conductoring of the Kelly-Seneca 115 kV line, did not cause the need for any additional upgrades, however, it did reduce the need for some other upgrades. The need for the reinforcement of the Kelly- Seneca 115 kV line is the direct result of adding the TransCanada pumping station loads.

The 2007 STEP found the need for a 10.9MVAR capacitor at South Seneca in the summer of 2008. The need for this capacitor is moved out to 2017 by adding the Knob Hill – South Beatrice 115kV line. The \$588,600 cost of this project can be delayed for 9-years.

Overloading on the Concordia-Clifton – Greenleaf 115kV-Greenleaf – Knob Hill 115kV lines is relieved by the addition of the Knob Hill – South Beatrice 115kV line. Therefore these lines would not need to be upgraded.

The Knob Hill- Beatrice 115 kV line with the associated terminal work and the re-conductoring of the Kelly-Seneca 115 kV line has a cost estimate of **\$21.7 million**. The proposed line is 35 miles in length with a 223/245 MVA summer rating. Westar has determined that the tentative in service date is 2010. This date matches the load in service date.

Knob Hill –Beatrice 115 kV	35.0 miles	\$17,600,000
Rebuild Kelly-Seneca 115 kV	10.3 miles	\$ 4,100,000
<b>Total</b>		<b>\$21,700,000</b>

### Clay Center Junction – Greenleaf 115kV

The initial results of the analysis show that the Clay Center Junction – Greenleaf 115kV line did not cause the need for any additional upgrades and did not reduce the need for other upgrades from the 2007 STEP.

Another issue has surfaced though during the study process. When the new load of TransCanada Keystone Pipeline Pump Station #29 is connected to the South Seneca 115kV bus, the addition of 18 MW causes the overloading of the Concordia – Greenleaf 115kV, Greenleaf – Knob Hill 115kV and Kelly – South Seneca 115kV lines. The Clay Center Junction – Greenleaf 115kV line does not relieve these overloads. Reconductoring these lines is the anticipated upgrade to relieve them. Estimated costs for the upgrades are outlined below:

Clay Center Junction – Greenleaf 115kV	30.0 miles	\$ 9,300,000
Rebuild Concordia – Greenleaf 115kV	37.8 miles	\$15,900,000
Rebuild Greenleaf – Knob Hill 115kV	20.9 miles	\$ 8,200,000
Rebuild Kelly-Seneca 115 kV	10.3 miles	\$ 4,100,000
<b>Total</b>		<b>\$37,500,000</b>

One added benefit of the Clay Center Junction – Greenleaf 115kV line is that it provides a second feed into Clay Center Junction. This significantly increases power reliability to that substation, but the reliability benefit is difficult to quantify.

### **Knob Hill – Steele City 115 kV**

The results of the analysis show that the Knob Hill – Steele City 115kV line, along with the re-conductoring of the Kelly-Seneca 115 kV line, did not cause the need for any additional upgrades, however, it did reduce the need for some other upgrades.

The 2007 STEP found the need for a 10.9MVAR capacitor at South Seneca in the summer of 2008. The need for this capacitor is moved out to 2017 by adding the Knob Hill – Steele City 115kV line. The \$588,600 cost of this project can be delayed for 9-years.

The Knob Hill- Steele City 115 kV line with the associated terminal work and the re-conductoring of the Kelly-Seneca 115 kV line has a cost estimate of **\$21.7 million**. The proposed line is approximately 35 miles in length with a 223/245 MVA summer rating. Westar has determined that the tentative in service date is 2010. This date matches the load in service date.

Knob Hill –Steele City 115 kV	35.0 miles	\$17,600,000
Rebuild Kelly-Seneca 115 kV	10.3 miles	\$ 4,100,000
<b>Total</b>		<b>\$21,700,000</b>

### **Clay Center Junction – Greenleaf 115kV with 2<sup>nd</sup> Kelly-Seneca Ckt.**

The results of the analysis show that the Clay Center Junction – Greenleaf 115kV line, along with the proposed Kelly-Seneca 2<sup>nd</sup> circuit 115 kV, did cause the need for two additional upgrades.

Those are the reconductoring of the Circleville-King Hill and the King Hill-Kelly 115 kV lines. Also the project did not reduce the need for other upgrades from the 2007 STEP.

Another issue surfaced during the study. The additional load of TransCanada Keystone Pipeline Pump Station #29 was connected to the South Seneca 115kV bus. Now this increased load, 18 MW, caused overloading of Clifton – Greenleaf 115kV, Greenleaf – Knob Hill 115kV and Kelly – South Seneca 115kV lines. The Clay Center Junction – Greenleaf 115kV line does not relieve these overloads. Installing a second 115 kV circuit between Kelly - Seneca did eliminate the need for reconductoring those lines. However, an addition problem was found requiring the re-conductoring of the Kelly- King Hill and King Hill- Circleville 115 kV lines. Estimated costs for the upgrades are outlined below:

Clay Center Junction – Greenleaf 115kV	30.0mi.	\$ 9,300,000
Kelly – Seneca 2 <sup>nd</sup> circuit 115kV	10.3mi.	\$ 9,000,000
Rebuild Circleville- King Hill 115kV	15.1mi.	\$ 6,400,000
Rebuild King Hill- Kelly 115 kV	9.6mi.	\$ 4,100,000
<b>Total</b>		<b>\$28,800,000</b>

One added benefit of the Clay Center Junction – Greenleaf 115kV line is that it provides a second feed into Clay Center Junction. This significantly increases power reliability to that substation, but the reliability benefit is difficult to quantify.

## CONCLUSIONS AND RECOMMENDATIONS

When the new TransCanada Keystone Pipeline pump station loads are taken into account, the Knob Hill – Steele City 115kV line with the corresponding re-conductoring of the Kelly-Seneca 115 kV line appears to provide a more attractive regional solution than the Clay Center Junction – Greenleaf 115kV line. Therefore the Knob Hill – Steele City 115kV line is the recommended option.

The City of Clay Center expressed their interest in building the Clay Center- Greenleaf 115 kV line as a second source per OMPA comments. SPP determined that the Clay Center- Greenleaf line would not create a reliability issue in conjunction with the proposed recommended project, the Knob Hill – Steele City line project.