SCAV CSVA
SOCIÉTÉ CANADIENNE D'ANALYSE DE LA VALEUR
CANADIAN SOCIETY OF VALUE ANALYSIS

Value Engineering and Risk Analysis for Tunnelling Projects Case Study : SA10a CSVA Conference 2012-Calgary

Siri Fernando, P.Eng,.
Hussien T. Al-Battaineh, Ph.D., P. Eng., AVS
Holly Parkis, BA, AVS

SMA

THE CITY OF Edmonton

Presentation Overview

- Introduction
- Value Engineering
- Risk Analysis
- Integrated Value Engineering & Risk Analysis
- Case Study SESS SA10a
- Conclusion

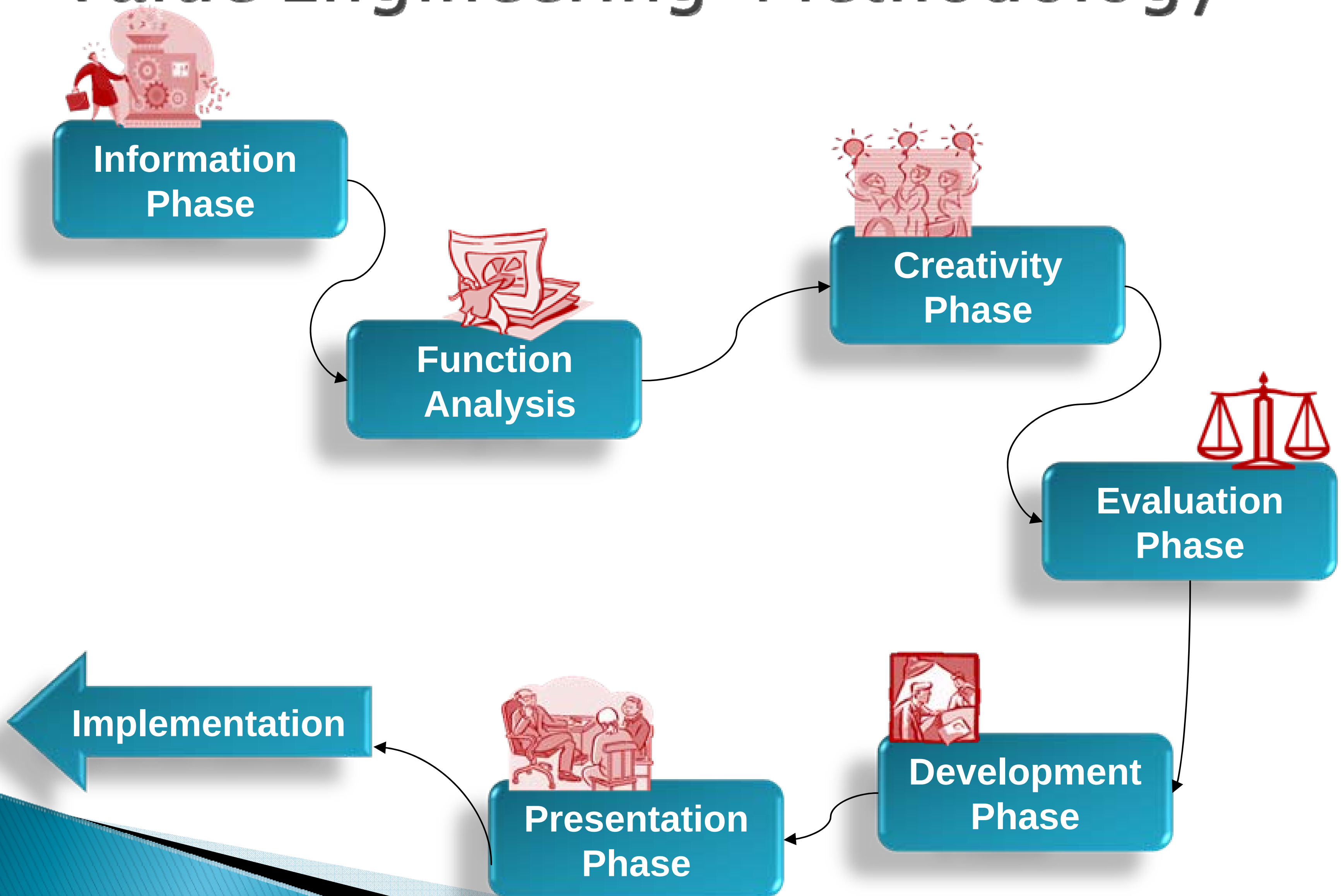
Introduction

- The City of Edmonton- Drainage Services conduct risk analysis and value engineering in most of their project to identify and mitigate risks, and to assure that the proposed option is the highest value option.
- An integrated Value Engineering and Risk Analysis has been developed and used to reduce rework and balance between creativity induced risks and options value
- This presentation will introduce the methodology and a sample case study

Value Methodology (SAVE Int)

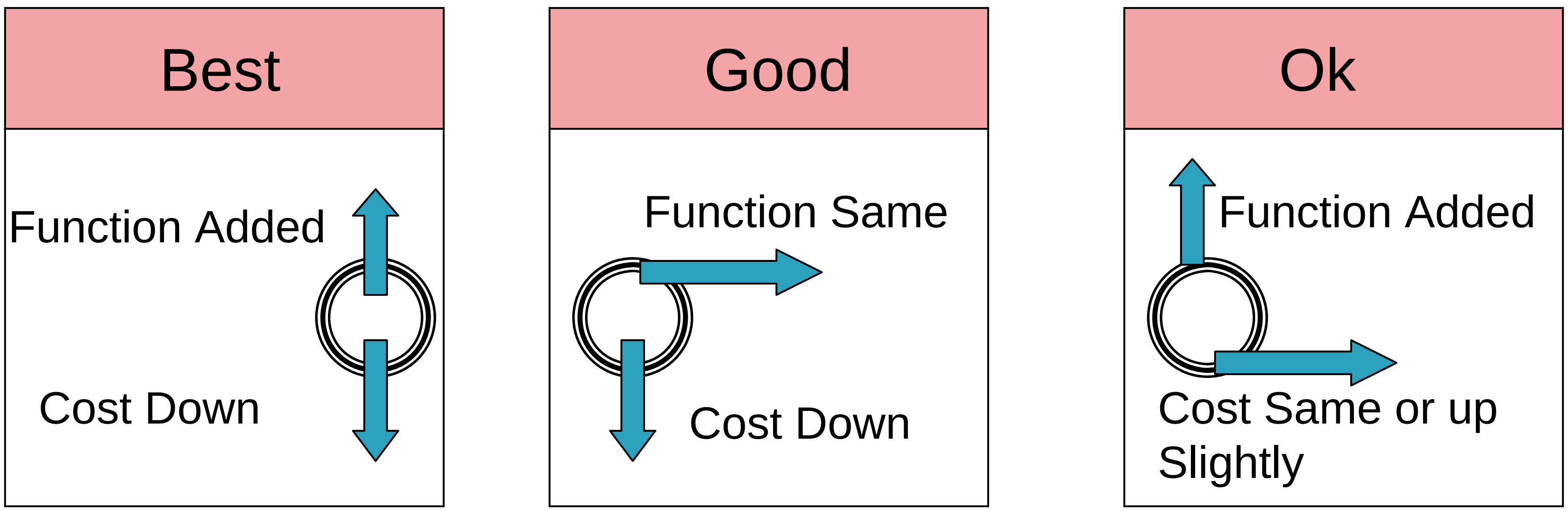
- Value methodology is:
  - a s*ystematic* process used by *multidisciplinary* team to *improve* the *value* of a project through the analysis of its *function*.
  - Function-oriented, systematic, team approach to add customer value to a program, facility, system or service. Improvement like performance, quality, initial and life cycle cost are paramount in the value methodology.

Value Engineering–Methodology



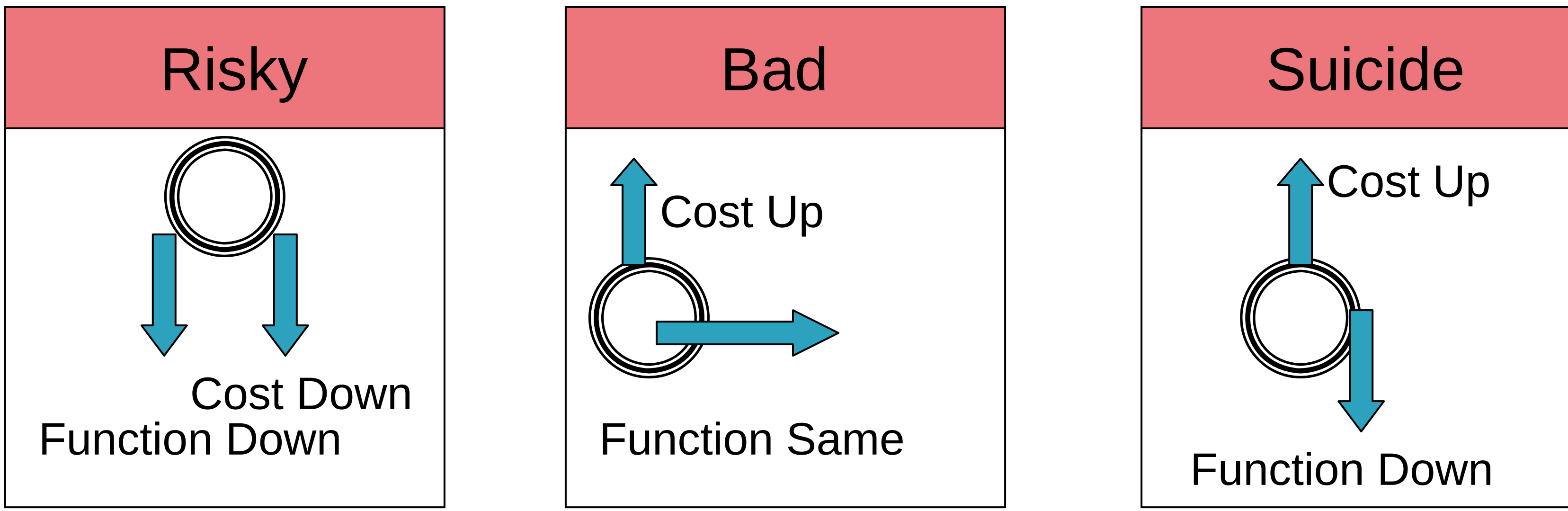
Value Engineering

Value Situation (Function vs. Cost)



Value Engineering

Value Situation (Function vs. Cost)



Value Engineering

- What is Value:

$$Value = \frac{\text{What we get out of something}}{\text{What we put into it}}$$

$$Value = \frac{\text{Quality, Reliability, Appeal, etc.}}{\text{Cost, Time, Mass, Energy, etc.}} = \frac{\text{Benefits}}{\text{Resources}}$$

$$Value = \frac{\text{Function}}{\text{Cost}}$$

Value = A ratio used for comparing alternatives that can reliably perform the same function

Risk Concepts

Risk:

The **possibility** of suffering **loss (or harm)** and the **impact** that loss has on the involved party. Risk can be characterized in terms of its severity, where:

Severity = Likelihood of Occurrence x Magnitude of the Impact

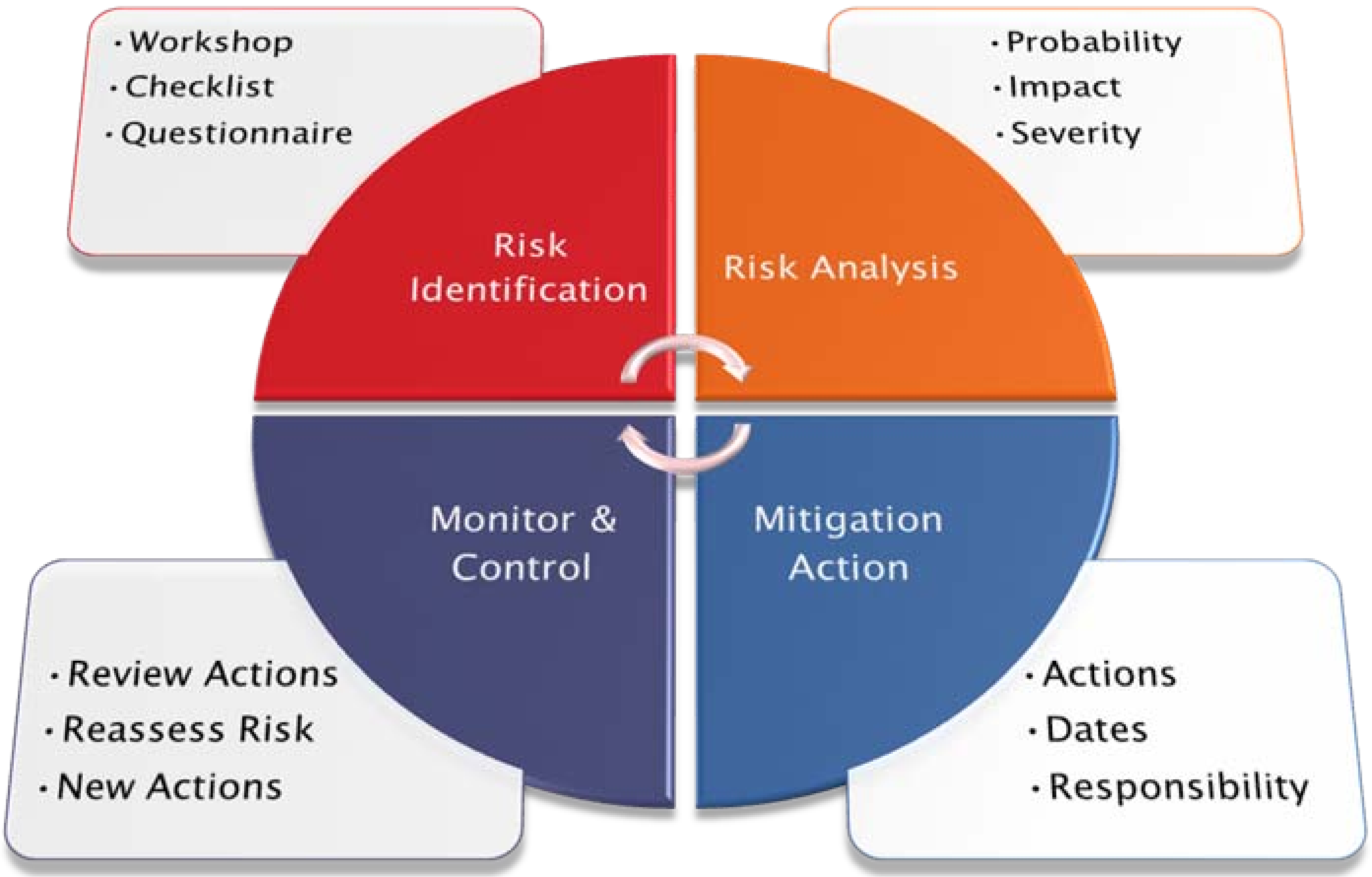
Opportunity:

The **possibility** of realizing a **favorable outcome** and the **impact** this outcome has on the involved party. Opportunity is **positive** risk and can be identified and managed in a similar way.

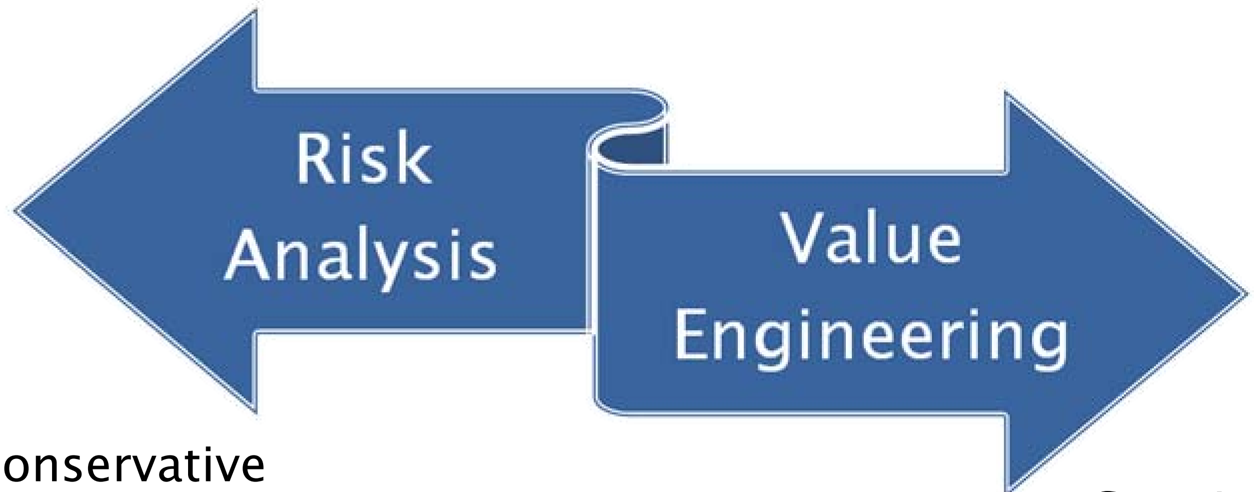
Uncertainty:

"The **gap** between the information **required** to estimate an outcome and the information already **possessed** by the decision maker." (CII 1989)

Risk Management Method



Contradiction



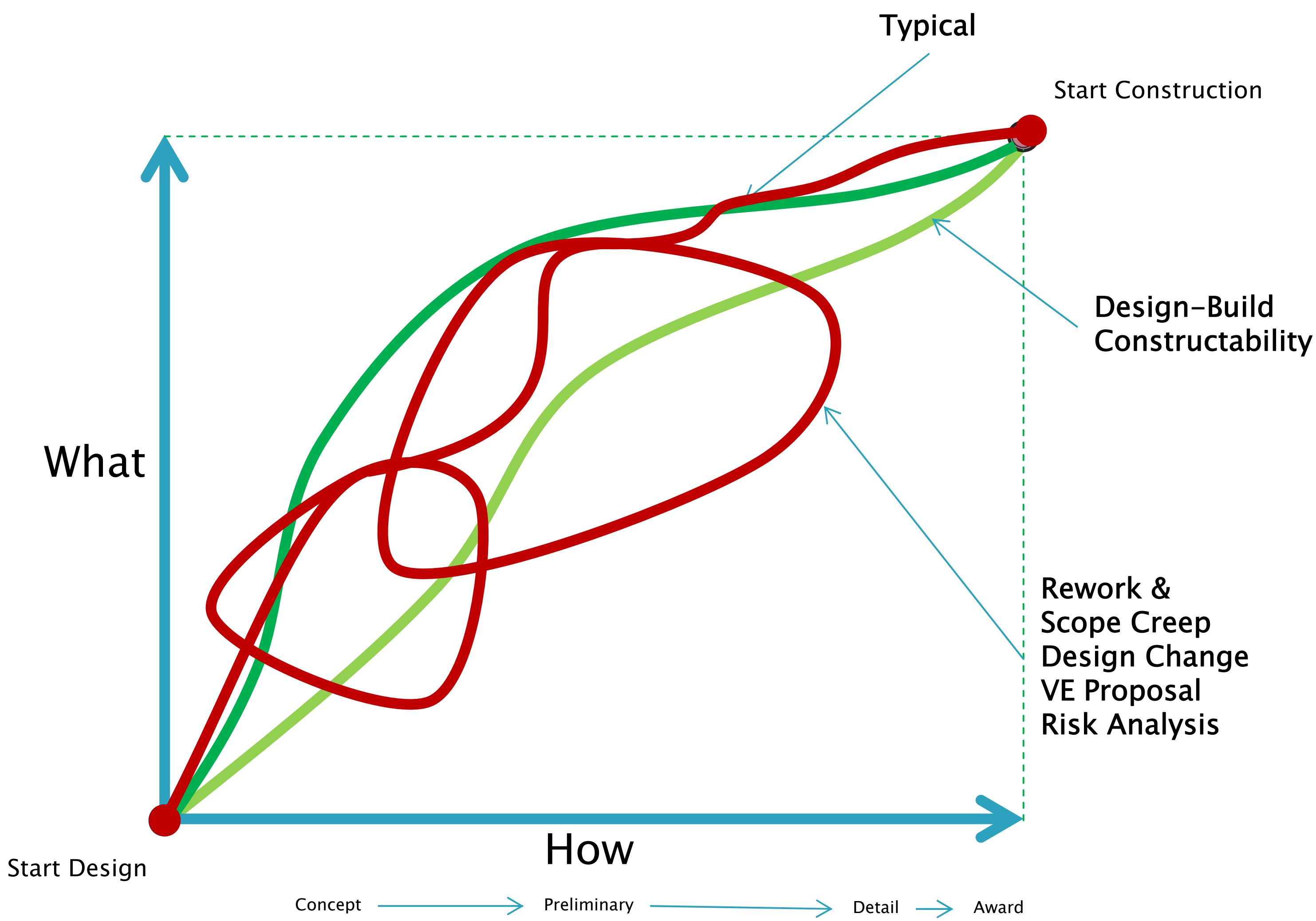
Conservative

Low Risk Tolerance

Creativity

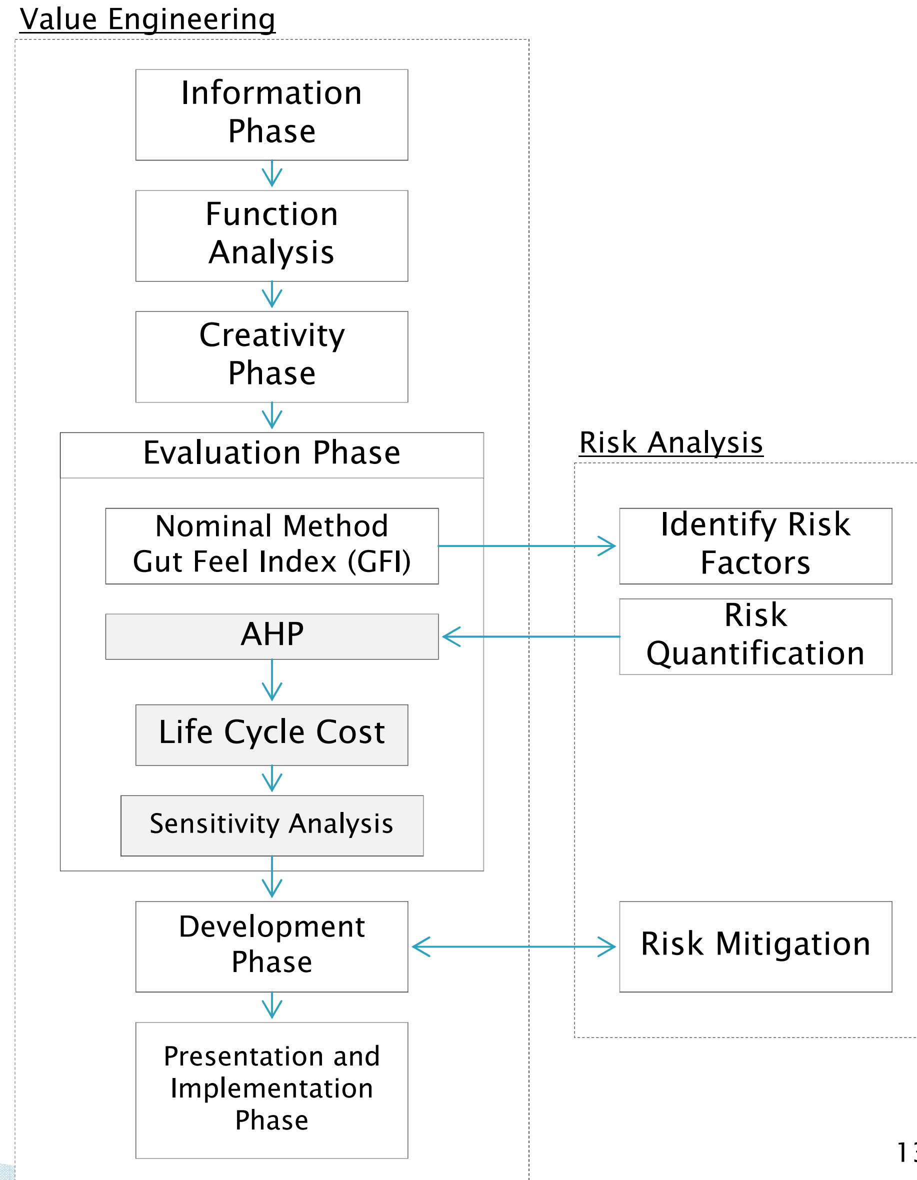
Free the Mind

Uncertainty Dimensions



Value Engineering &Risk Analysis

- Value Engineering push the limits and raise the par– *be creative*
- With creativity we might increase uncertainty– *Risk*
- It is vital to account for risk in a value engineering session
- Life cycle cost is associated with *uncertainty* related to financial assumptions



Case Study-SA10

- VE & RA was conducted in 2011
- The workshop objective were:
  - To select the highest value options for the SA10 alignment (vertical and horizontal), tie in points, and lift station location.
  - Identify all potential risks and establish risk mitigation plan
  - Project information (SSSF , project motivation)
  - Function Analysis
  - Creativity Phase: 7 options
  - Risk Analysis (Identification, Quantification)
  - Evaluation Phase & Sensitivity Analysis

Conclusions

- Creativity presents opportunities to improve the project functions but at the same time might introduce uncertainty and risk to the project
- Evaluating the uncertainty associated with analysis assumptions provide essential information to make an informed decision
- Value engineering is flexible methodology which could be incorporated with many management tools
- The workshop objectives were achieved and the project is going to detailed design and construction soon.

Questions

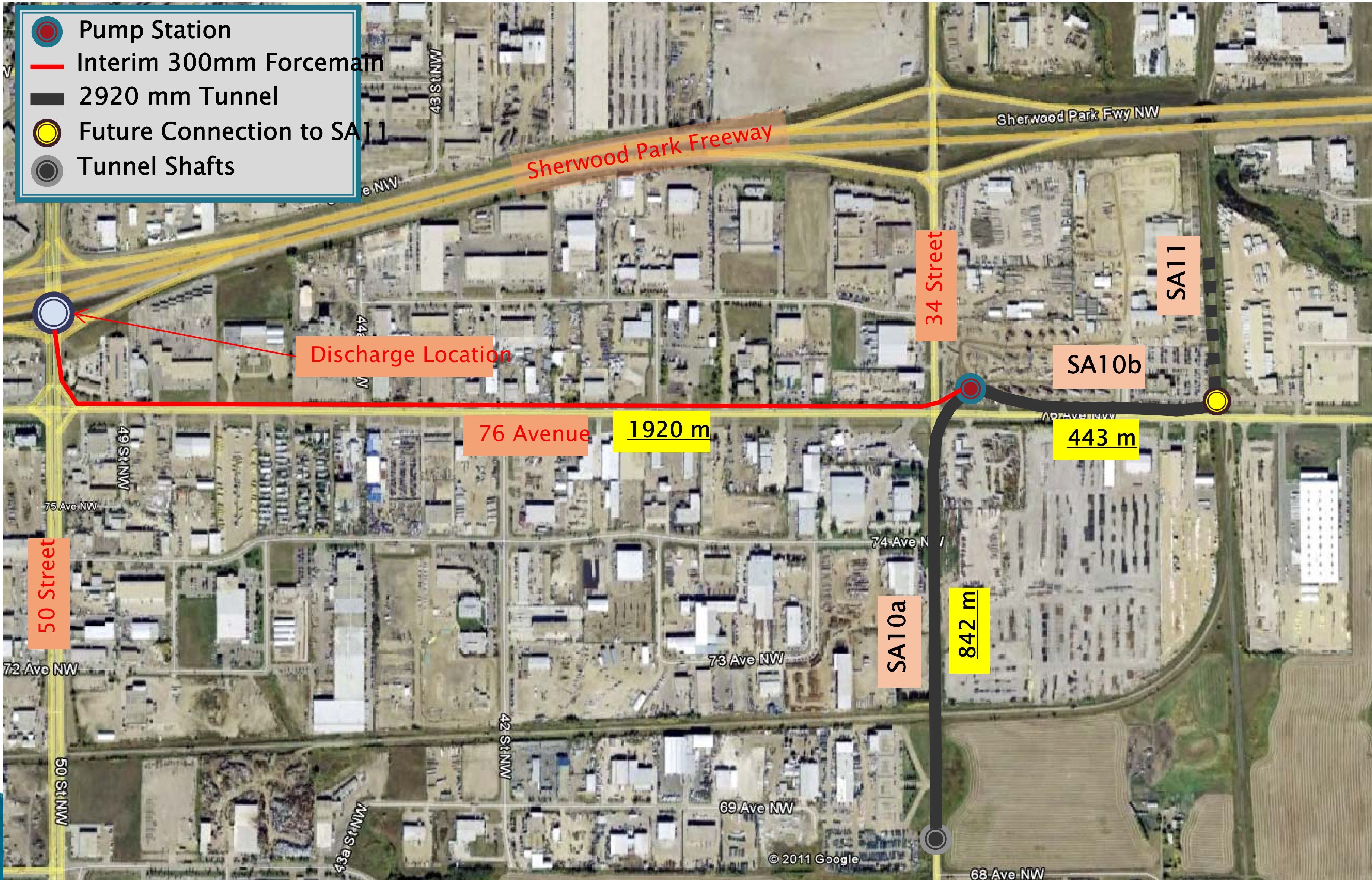
Function Analysis

Number	Function	Type - Interim	Type - Ultimate
1	Convey Flow	Basic Function	Basic Function
2	Store Flow	Basic Function	Secondary Function
3	Facilitate Growth	High Level Function	High Level Function
4	Reduce Odour	Secondary Function	Secondary Function
5	House Equipment	Secondary Function	Secondary Function
6	Reduce Flooding	Secondary Function	Secondary Function
7	Satisfy Stakeholders	High Level Function	High Level Function
8	Maintain Standards	All timeContinuous Function	All time Continuous Function

Creativity Phase

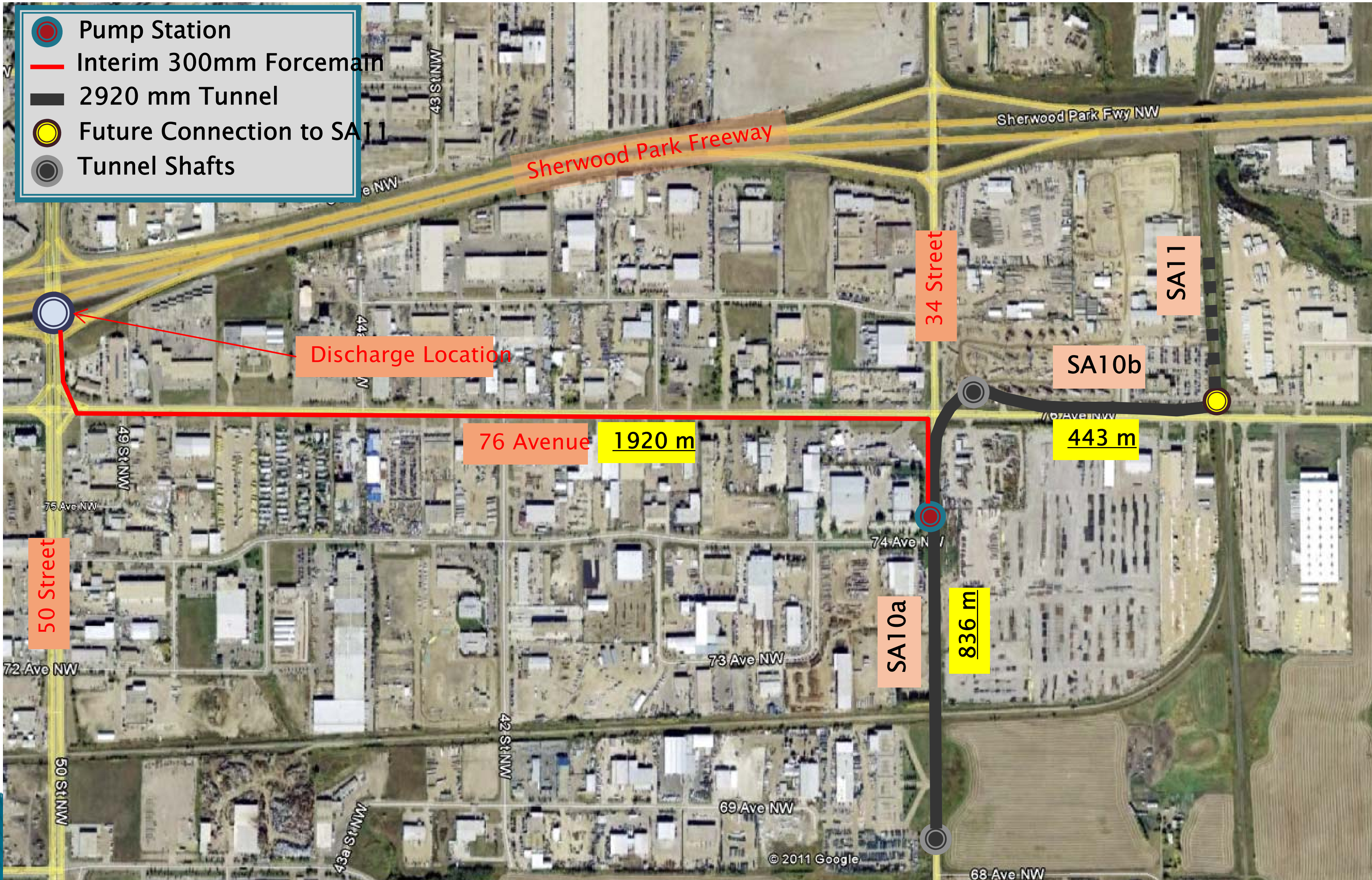
Option	Description	Staging
1	Build SA10a and locate pump station on the north east corner of 76 Avenue and 34 Street and build SA10b when needed (after 17 years or 68 years)	Stage SA10
2	Build SA10a and locate retrieval shaft on the north east corner of 76 Avenue and 34 Street. Build pump station along the alignment around 74 Avenue and 34 Street. Later, build SA10b when needed (after 17 years or 68 years)	Stage SA10
3	Build SA10 and curve the tunnel around 76 Avenue and 34 Street.	Build SA10
4	Build SA10 as a straight line crossing under the industrial area at the west south corner of 76 Avenue and 34 Street.	Build SA10
5	Build SA10a and locate the retrieval shaft and pump station shaft at the southwest corner of 76 Avenue and 34 Street. Later, build SA10b when needed (after 17 years or 68 years)	Stage SA10
6	Build SA10a and locate the retrieval shaft and pump station shaft at the northwest corner of 76 Avenue and 34 Street. Later, build SA10b when needed (after 17 years or 68 years)	Stage SA10
7	Build SA10 by constructing an equivalent length along 34 Street (up to Sherwood Park freeway), and locate the pump station in the freeway median. This option changes the original alignment of the SESS Tunnel.	Build SA10

Option1



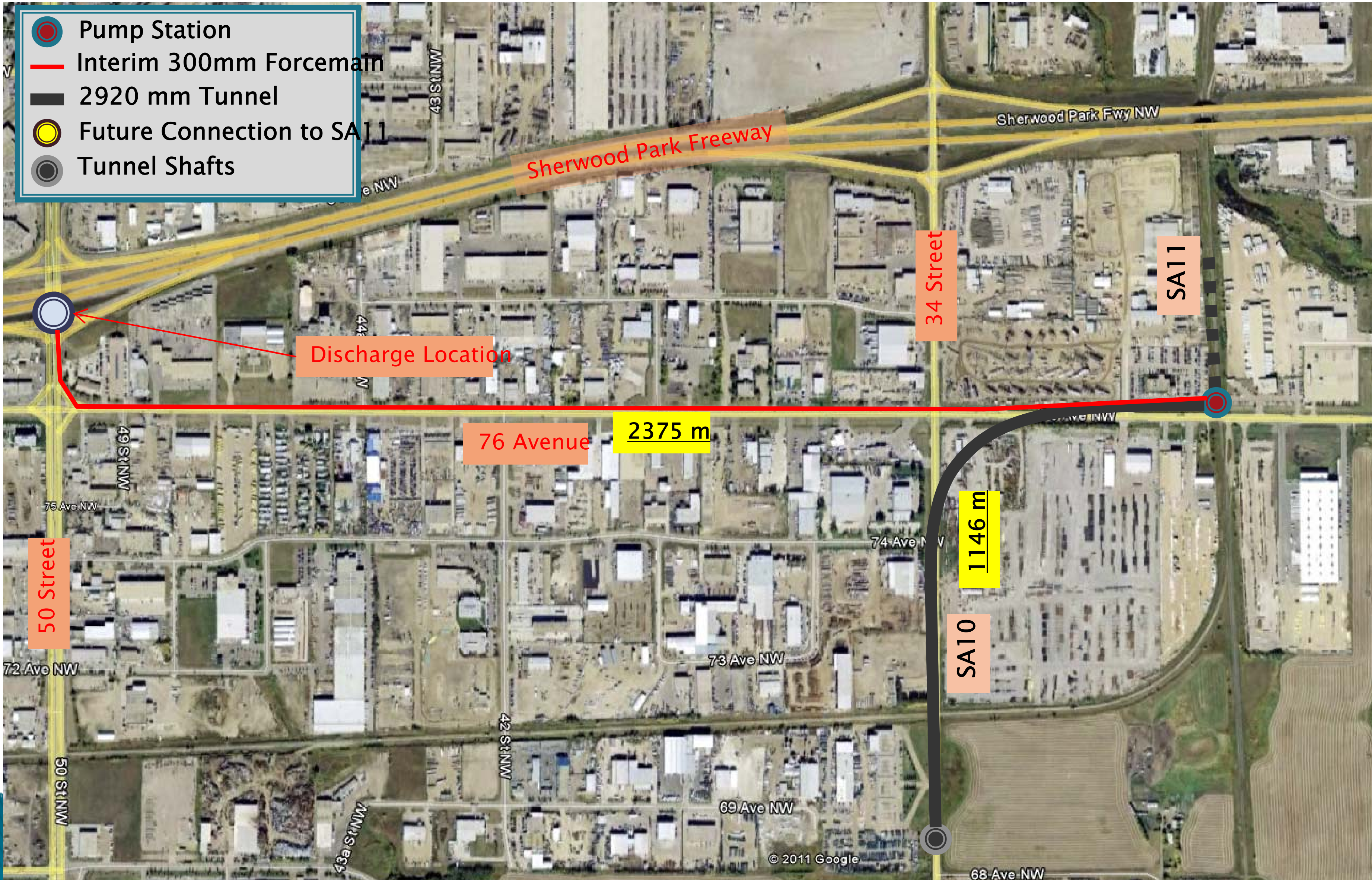
Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
34 Street
SA11
SA10b
Discharge Location
76 Avenue
1920 m
443 m
50 Street
SA10a
842 m
75 Ave NW
74 Ave NW
73 Ave NW
72 Ave NW
69 Ave NW
68 Ave NW
43 St NW
49 St NW
42 St NW
50 St NW
43a St NW
© 2011 Google

Option2



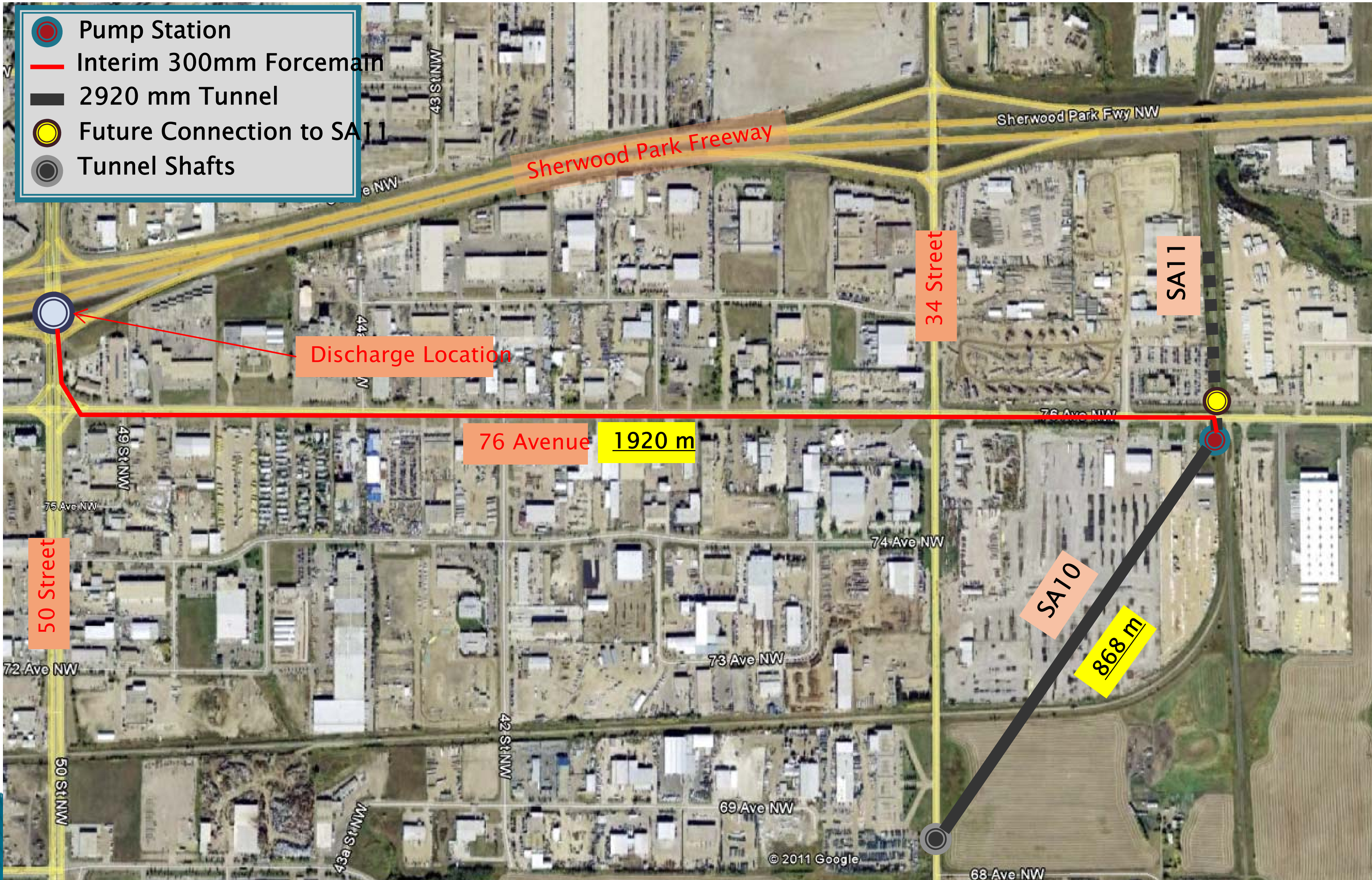
Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
34 Street
SA11
SA10b
Discharge Location
76 Avenue
1920 m
443 m
50 Street
SA10a
836 m
43 St NW
49 St NW
42 St NW
50 St NW
43a St NW
75 Ave NW
74 Ave NW
73 Ave NW
72 Ave NW
69 Ave NW
68 Ave NW
© 2011 Google

Option3



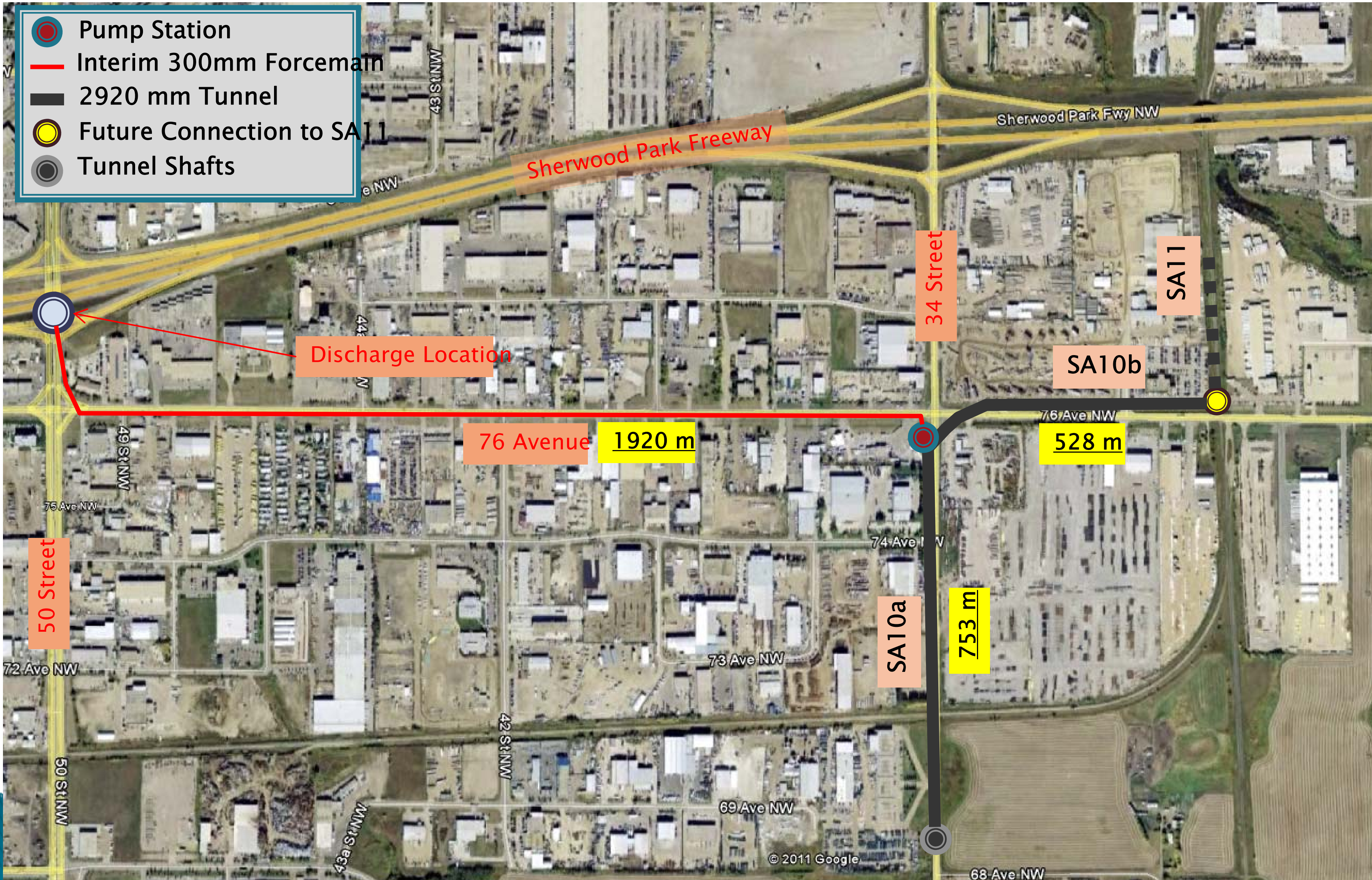
Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
Discharge Location
34 Street
SA11
76 Avenue
2375 m
1146 m
SA10
50 Street
43 St NW
49 St NW
75 Ave NW
74 Ave NW
73 Ave NW
72 Ave NW
42 St NW
69 Ave NW
68 Ave NW
50 St NW
43a St NW
© 2011 Google

Option4

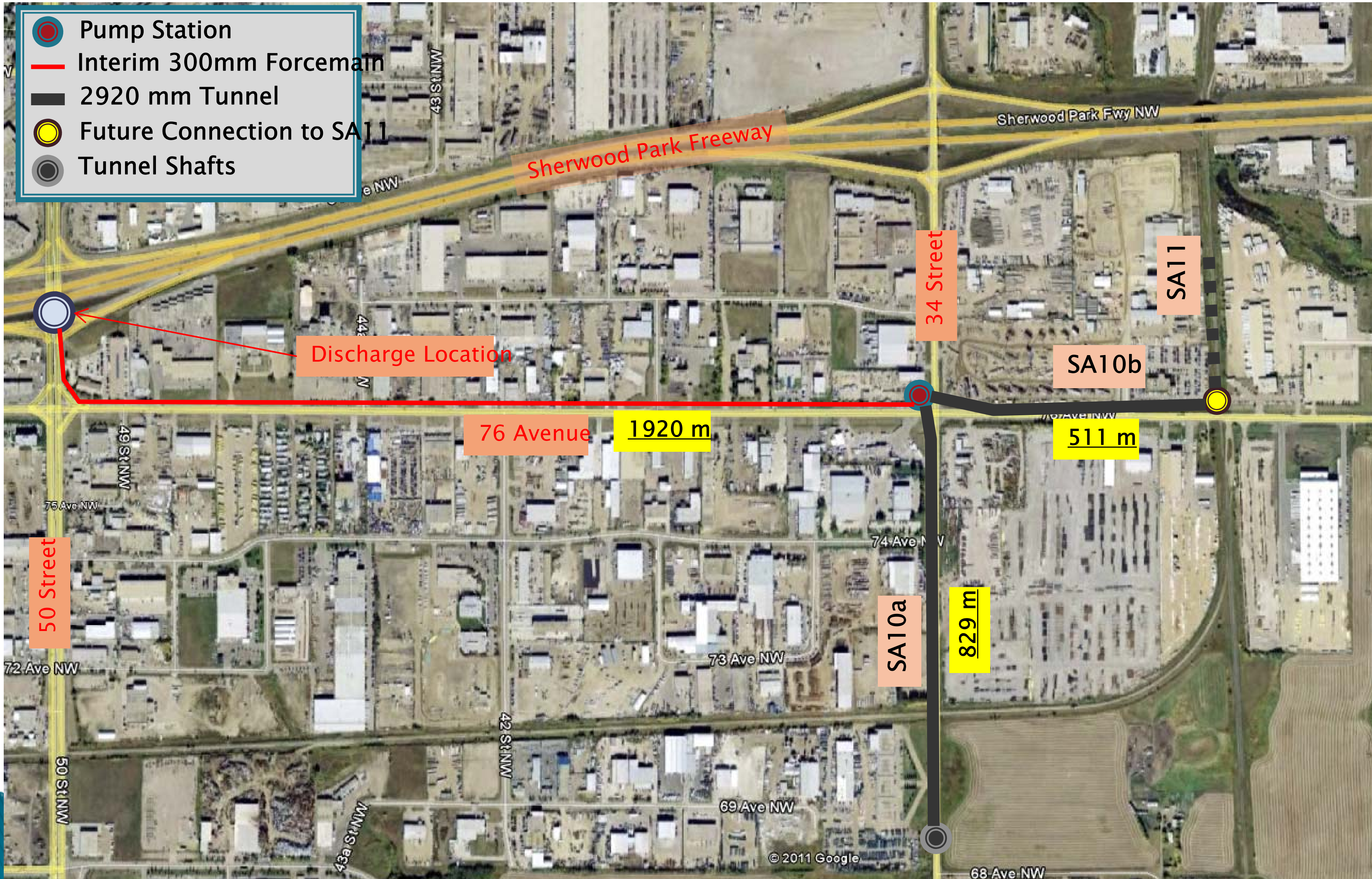


Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
34 Street
SA11
Discharge Location
76 Avenue
1920 m
76 Ave NW
50 Street
74 Ave NW
SA10
868 m
73 Ave NW
72 Ave NW
75 Ave NW
49 St NW
43 St NW
42 St NW
50 St NW
43a St NW
69 Ave NW
68 Ave NW
© 2011 Google

Option5

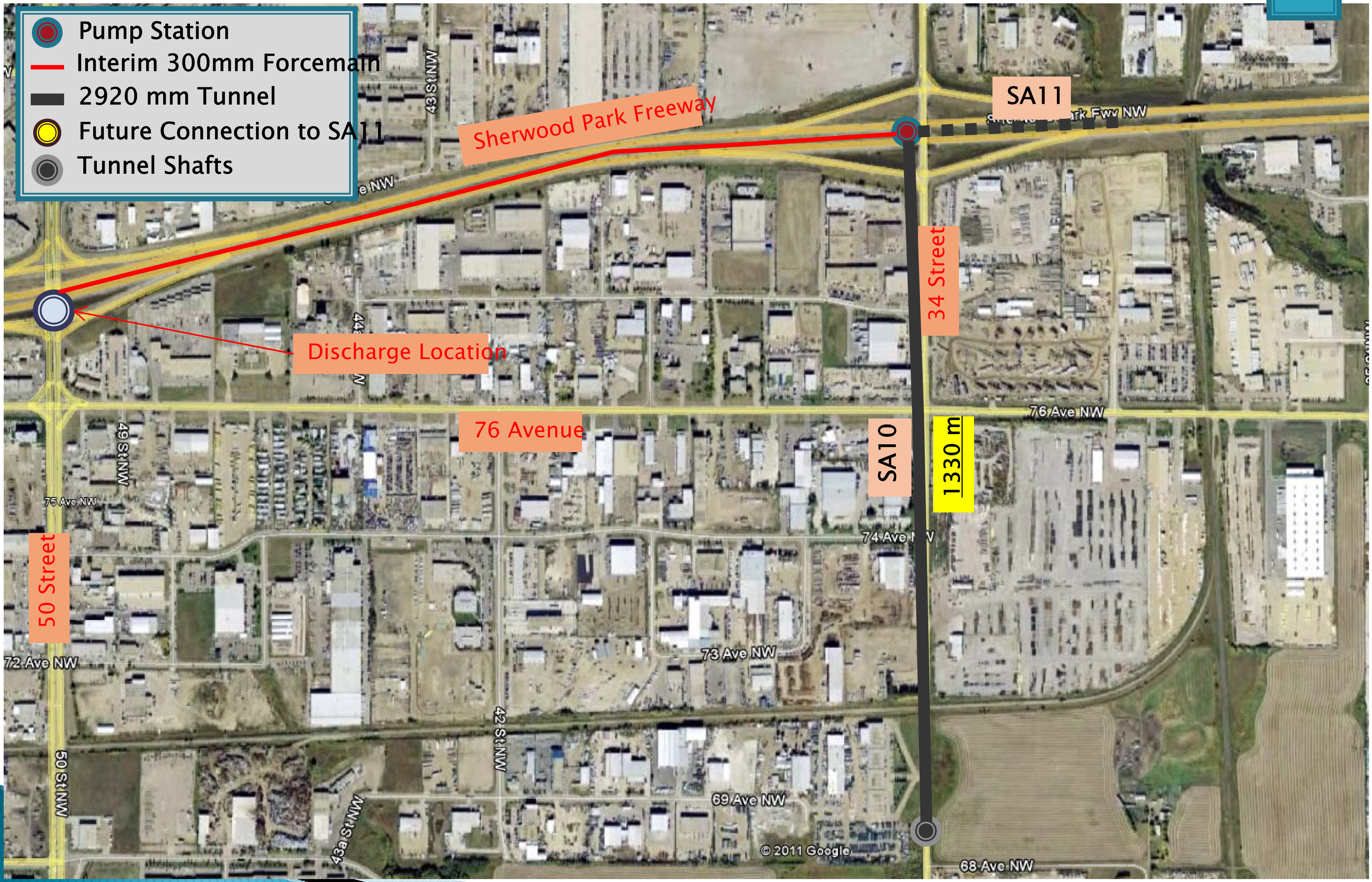

Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
34 Street
SA11
SA10b
Discharge Location
76 Avenue
1920 m
76 Ave NW
528 m
50 Street
SA10a
753 m
43 St NW
49 St NW
75 Ave NW
74 Ave NW
72 Ave NW
73 Ave NW
42 St NW
50 St NW
69 Ave NW
43a St NW
68 Ave NW
© 2011 Google

Option6



Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
Sherwood Park Freeway
Sherwood Park Fwy NW
34 Street
SA11
SA10b
Discharge Location
76 Avenue
1920 m
511 m
50 Street
SA10a
829 m
43 St NW
49 St NW
75 Ave NW
74 Ave NW
73 Ave NW
72 Ave NW
42 St NW
69 Ave NW
68 Ave NW
50 St NW
43a St NW
© 2011 Google

Option7



Pump Station
Interim 300mm Forcemain
2920 mm Tunnel
Future Connection to SA11
Tunnel Shafts
SA11
Sherwood Park Freeway
Discharge Location
34 Street
76 Avenue
SA10
1330 m
50 Street
76 Ave NW
74 Ave NW
73 Ave NW
72 Ave NW
69 Ave NW
68 Ave NW
75 Ave NW
49 St NW
43 St NW
42 St NW
43a St NW
50 St NW
© 2011 Google

Risk Analysis

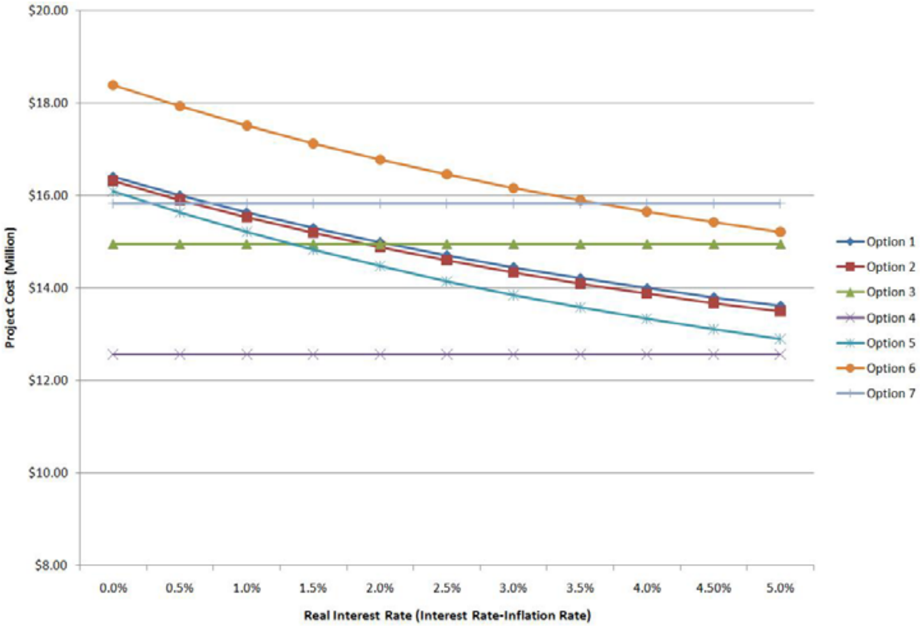
Sample risk factors

#	Risk Factor	Likelihood	Magnitude	Severity	$ Impact
1	Strata easements/ land acquisition may not materialize according to our staging timeframe because owners may not cooperate, which may delay the project	Somewhat Likely	Substantial	Serious	$ 0.714
2	Encountering methane gas during shaft or tunnel construction may delay construction and add to costs (from reduced productivity and progress due to special handling requirements etc.).	Highly Likely	Marginal	Important	$ 0.071

Evaluation Phase

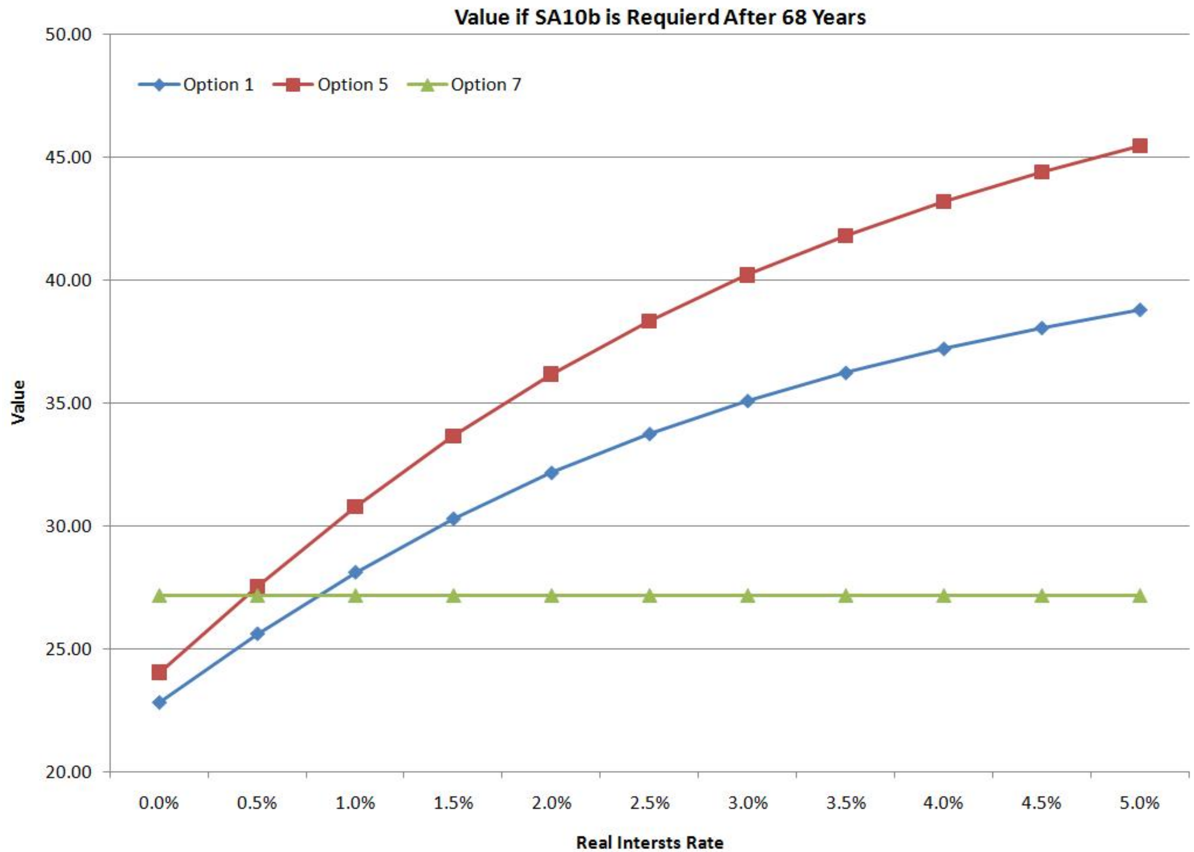
Function

		Option 1		Option 5		Option 7	
Criteria	Weight	Rating (100)	Score	Rating (100)	Score	Rating (100)	Score
Constructability	50%	70	34.9	80	39.9	100	49.9
Operation	21%	100	21.3	90	19.2	70	14.9
Impact to Public	11%	80	8.7	70	7.6	60	6.5
Stageability	18%	100	17.9	100	17.9	80	14.3
			82.9		84.6		85.7



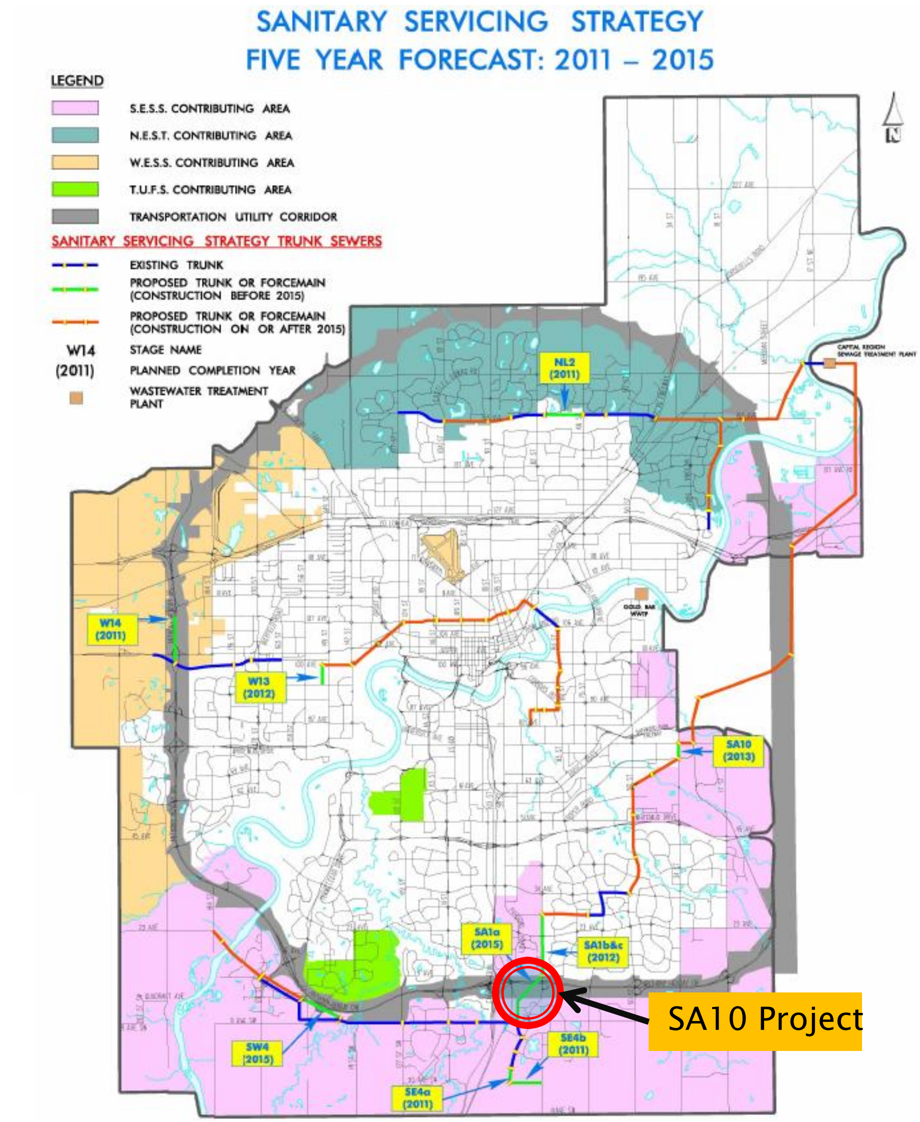
$$Value = \frac{\text{Function}}{\text{LCC Cost including Risk}}$$

Evaluation Phase



Sanitary Servicing Strategy Fund (SSSF)

- The SSSF is used to build sewers larger than 1,050mm in diameter that serve areas greater than 1,400 ha.
- Projects are selected and prioritized based on development needs while sustaining a positive balance throughout the term of the plan



SESS SA10– Project motivation

- Facility planning study concluded the following:
  - build Stage 1 storage and conveyance facility plan, named SESS SA10a
  - Consist of 770 m of 2920 mm diameter tunnel, complete with lift station and forcemain.
  - The lift station and forcemain are to discharge sanitary flows into the Sherwood Park Freeway Trunk

SA10 Project Issues

- Avoid mine shafts (issues with being filled with water)
- Vertical alignment should allow for both options, either going to Gold Bar or regional plants, by gravity.
- Maintain approved upstream connection point location