Sustainable Remediation Practices At A Gas Well Site in Alberta, Canada

Presentation Outline

- Background
  - Foreword
  - Sustainable Remediation
  - Shell's Internal Initiatives
  - Burnt Timber 2 (BT2)
- **Eco**Nomics ™ Assessment Methodology
- Burnt Timber 2 (BT2) **Eco**Nomics ™ Assessment
  - Framing Workshop
  - Options Investigated
  - Financial Components and Assumptions
  - External Components and Assumptions
  - Summary Costs
  - DELT• 3 Modelling Results
  - Limitations
  - Conclusions & Considerations

Foreword

“Shell has been at the center of sustainable remediation in the United Kingdom for a number or years. Recently faced with the regulatory-driven need to remediate a former drilling sump in Alberta we wanted to apply the principles of sustainable remediation to the site to determine if it would influence our remediation decisions. As a result, we engaged WorleyParsons to use its EcoNomics Assessment process to build upon the Phase I and II environmental site assessments and ecological and human health assessments they had already conducted at the site. The EcoNomics Assessment expanded our decision lens to include the communities impacted by the 1,000 plus heavy trucks that would pass through them on their 320 km round-trip journey to the landfill, not to mention the numerous water crossings and untold potential encounters with wildlife. **This assessment has created a positive dialogue with many of our key stakeholders including our regulators, local community groups and our industry peers. It is the first time, we have been able to definitively demonstrate that environmental and social risk (and damage) associated with regulatory compliance does not start and stop at the well-site or facility. In certain instances, our remediation efforts can pose greater risks than many on-site solutions.** WorleyParsons’ EcoNomics Assessment process is another tool we can use to effect balanced decisions that meaningfully engage with account for the needs of our external and internal stakeholders.”

Background: Sustainable Remediation

- Defined by Sustainable Remediation Forum United Kingdom (SuRF-UK) Forum as:

"The practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater that its impact, and that the optimum remediation solution is selected through the use of a balanced decision-making process."

Key Principles of Sustainable Remediation

- Principle 1: Protection of human health and the wider environment
- Principle 2: Safe working practices
- Principle 3: Consistent, clear and reproducible evidence-based decision-making
- Principle 4: Record keeping and transparent assumptions
- Principle 5: Good governance and stakeholder involvement
- Principle 6: Sound science

(SuRF-UK, 2010)

Step Wise Procedure for Sustainability Assessment

1. Identifying a need
2. Identifying which stakeholders to involve
3. Agreeing on objectives of the assessment
4. Agreeing on the scope of the assessment
5. Agreeing on the sustainability assessment approach
6. Execution of the sustainability appraisal
7. Verification

(Bardos et al, 2011 – adapted from SuRF-UK and NICOLE SR-WG)

SuRF-UK Possible Sustainable Remediation Indicator Categories

Environmental	Social	Economic
1. Impact on air	1. Impacts on human health and safety	1. Direct economic costs and benefits
2. Impact on water	2. Ethical and equity considerations	2. Indirect economic costs and benefits
3. Impact on soil	3. Impacts on neighbourhoods or regions	3. Induced costs
4. Impact on ecology	4. Community involvement and satisfaction	4. Employment and capital gain
5. Natural resource use and waste generation	5. Compliance with policy objectives and strategies	5. Life-span and "*project risks*"
6. Intrusiveness	6. Uncertainty and evidence	6. Project flexibility

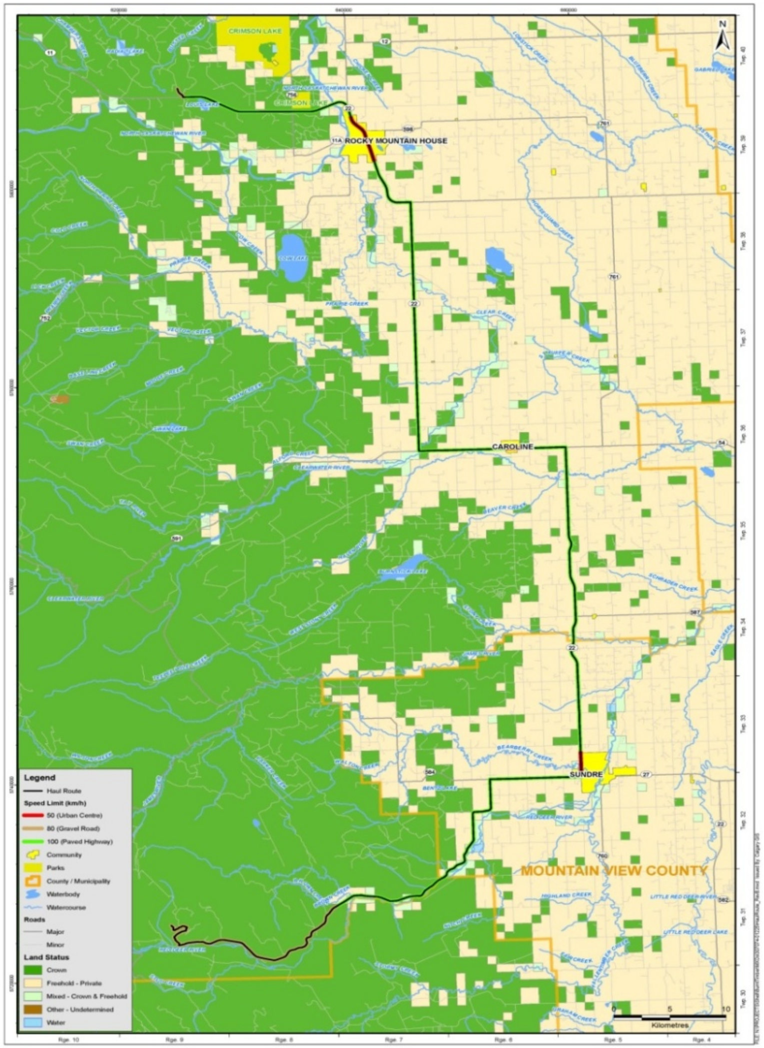
Shell's Internal Initiatives

- Guiding Principles of Sustainable Development
- Downstream Sustainability Remediation Initiatives (& discussions)
- Footprint Management
- Stakeholder Engagement (Internal, External, Local, & Political)

Burnt Timber 2 Site

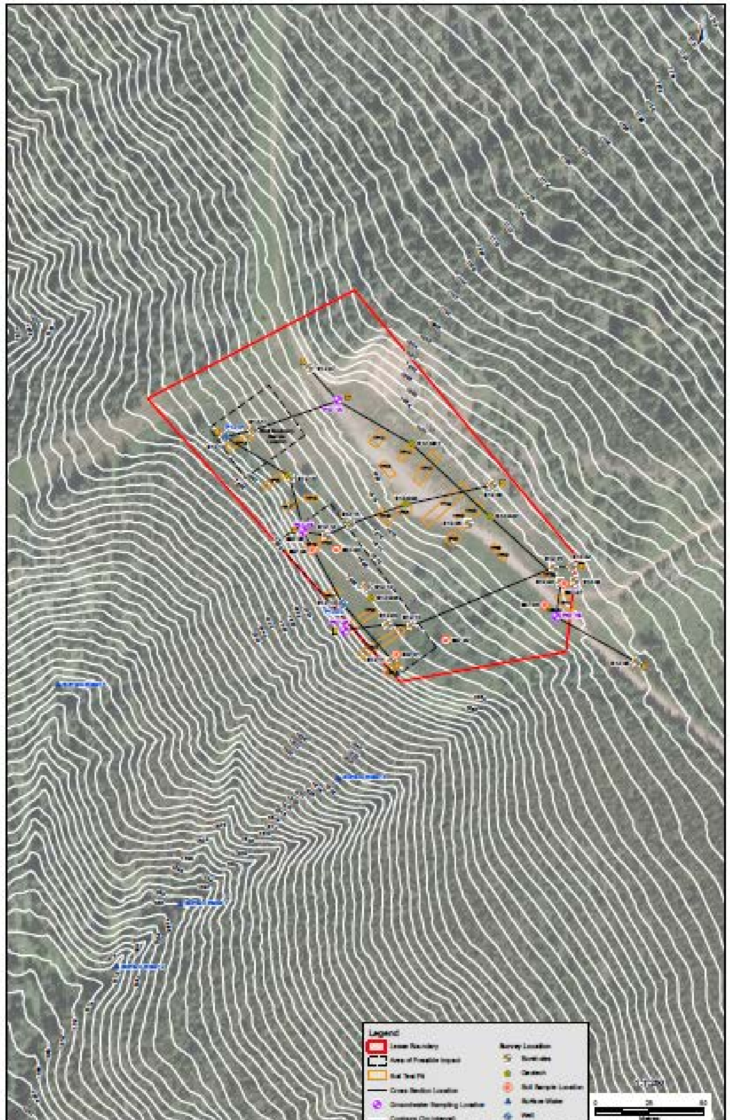
Burnt Timber 2 Site

Burnt Timber 2: The Context



- Burnt Timber 2 is remotely located in the Foothills
- Land is owned by the Crown and has "Green" land classification; located within a grazing allotment area
- Well was licensed, spudded and completed in 1959; put into production in 1968; and abandoned in 2005
- Site contains buried drilling mud wastes
- Distance to nearest landfill – 150 km
- No domestic/agricultural wells within 1 km of site
- Trucking and disposal scenario would require movement of up to 1,000 truckloads (~34,000 tonnes) of contaminated soil
- Trucks would pass through Sundre, Caroline and Rocky Mountain House

Activities Conducted at BT2 To Date

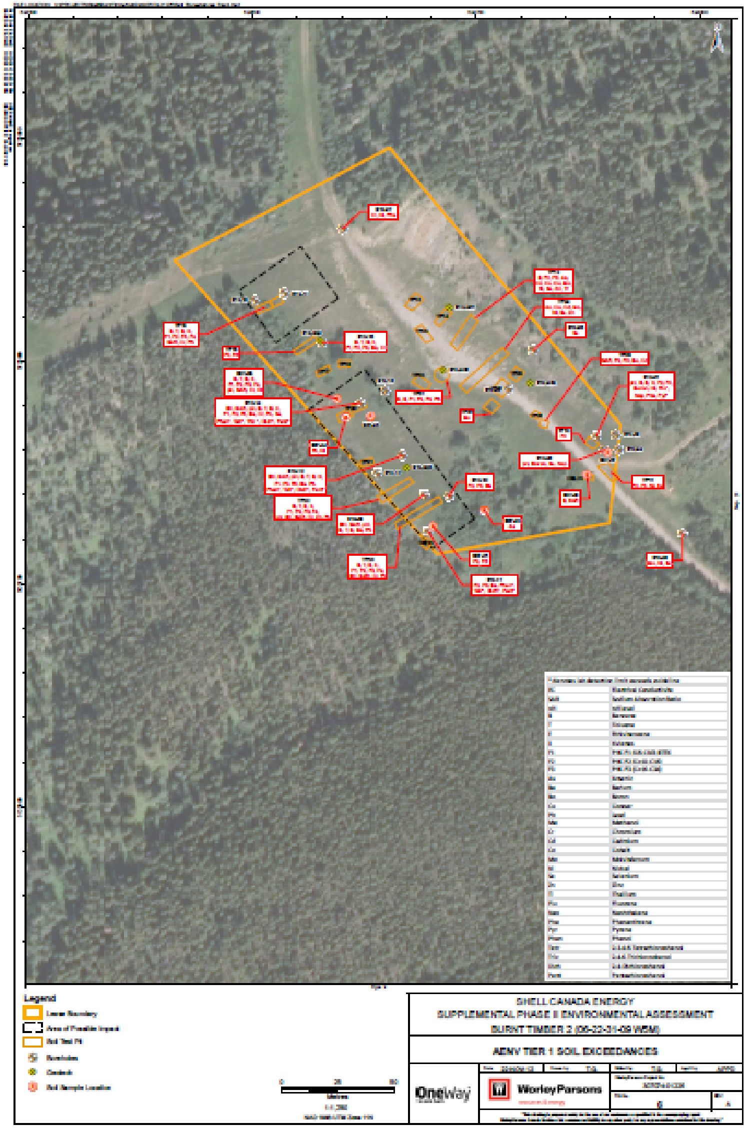


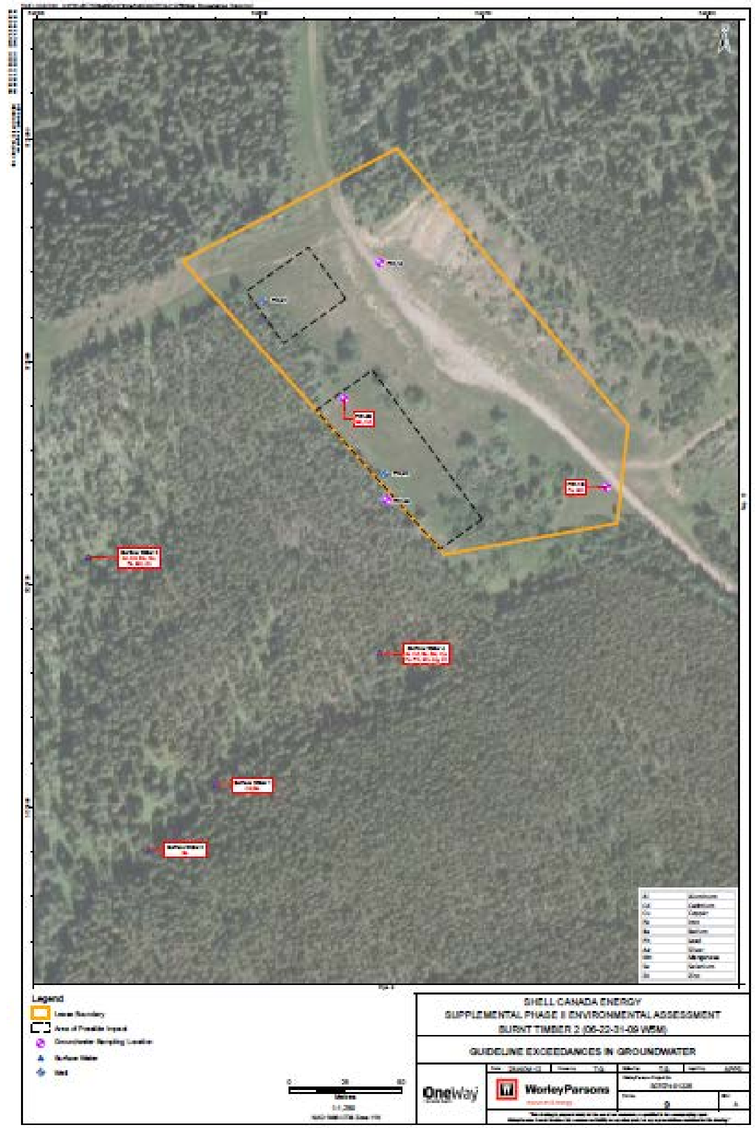
Activities Conducted at BT2 To Date

- Historical Investigation/Assessment
  - Phase I ESA (2005)
  - Phase II ESA (Test Pits, 2007)
  - Phase II ESA (Boreholes, 2007)
  - Groundwater Monitoring 2007 through 2012)

- Current 2012 Investigation/Assessment
  - Geophysical Survey (EM, ERT and GPR)
  - Geological Mapping
  - Phase II ESA (Delineation soil boreholes and Groundwater boreholes at base of sump Test Pits
  - Geotechnical Investigation (Boreholes and Stability Assessment)
  - Vegetation Assessment
  - Sustainability Assessment

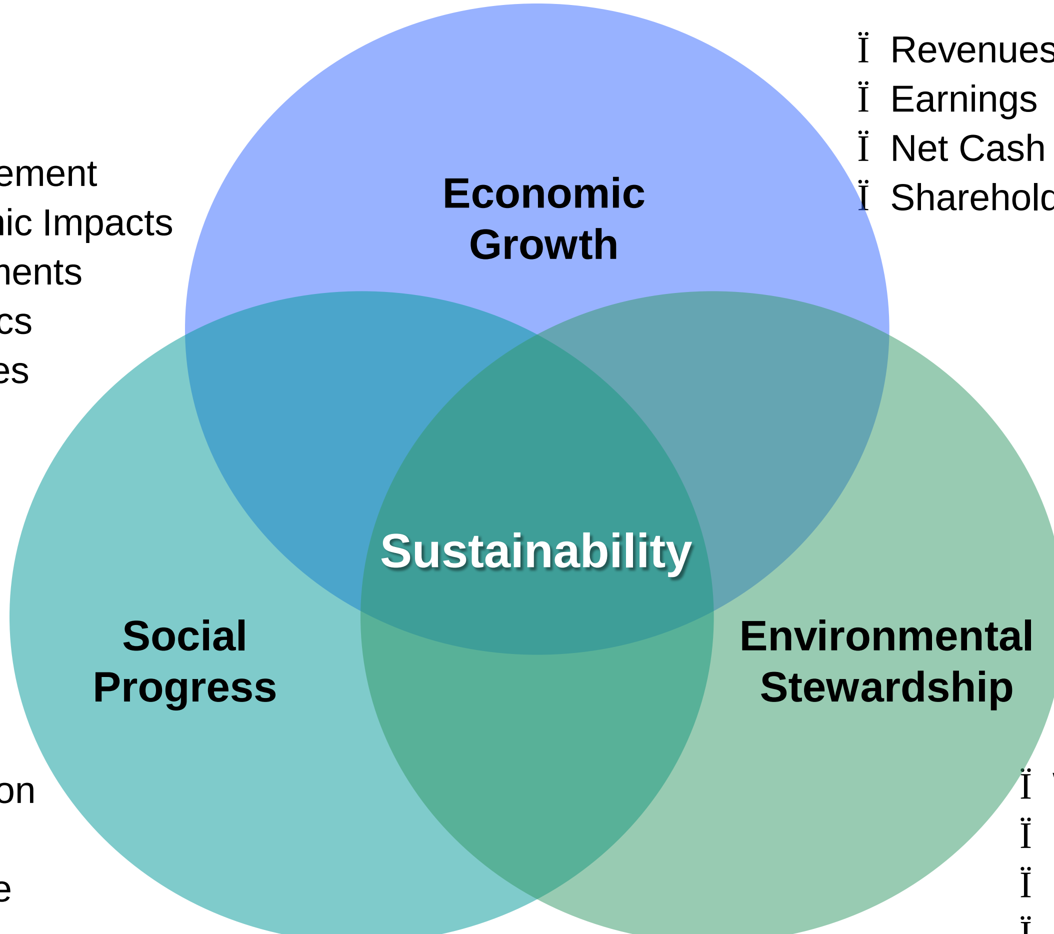
Site Diagram with Contaminant Levels





EcoNomics^{TM} Assessment Process – A Practical Application of Sustainable Remediation

Internal and External Drivers



- Revenues
- Earnings
- Net Cash Flow
- Shareholder Return

- Jobs Created
- Skills Enhancement
- Local Economic Impacts
- Social Investments
- Business Ethics
- Taxes/Royalties

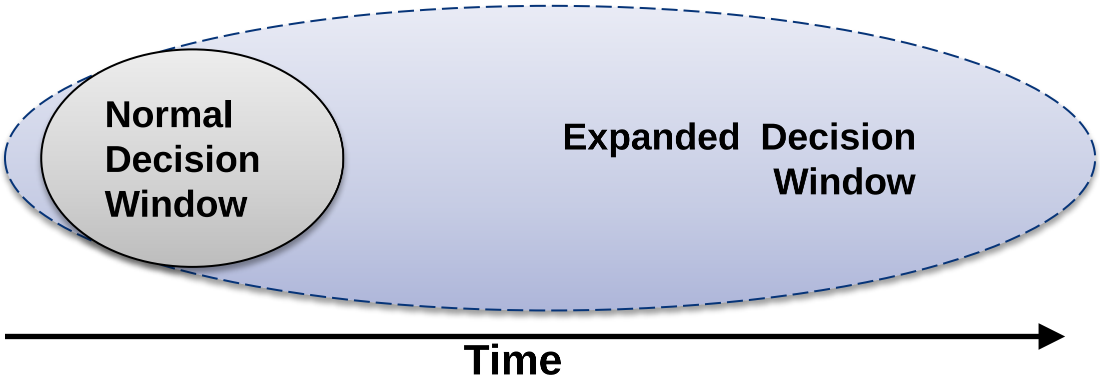
- Resource Efficiency
- Product Stewardship
- Life-Cycle Analysis
- Footprint Assessment

- Diversity
- Employee Satisfaction
- Human Rights
- Community Dialogue
- Labour Standards
- Corruption

- Waste Minimization
- Emissions Reduction
- Regulatory Compliance
- Biodiversity
- Spill Prevention

- Safety & Health
- Global Climate Change
- Resource Management
- Community Impacts

Considerations



Sustainable decisions recognize and value the relationships that exist between multiple risks and opportunities …

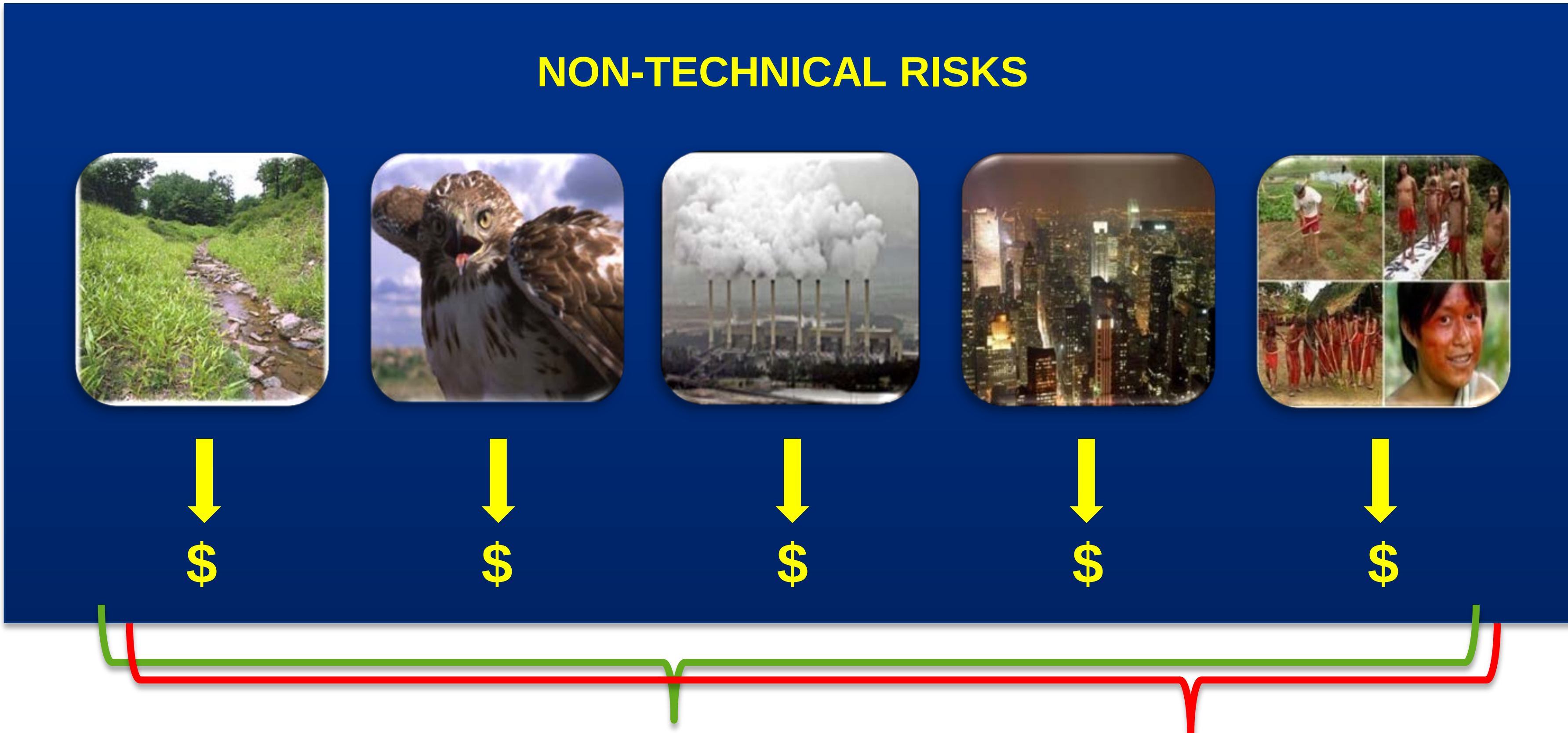
over the long term

Sustainable Decisions

- **An EcoNomics™ Assessment enhances decision quality by quantifying financial and non-financial benefits, costs and risks to inform decision making**

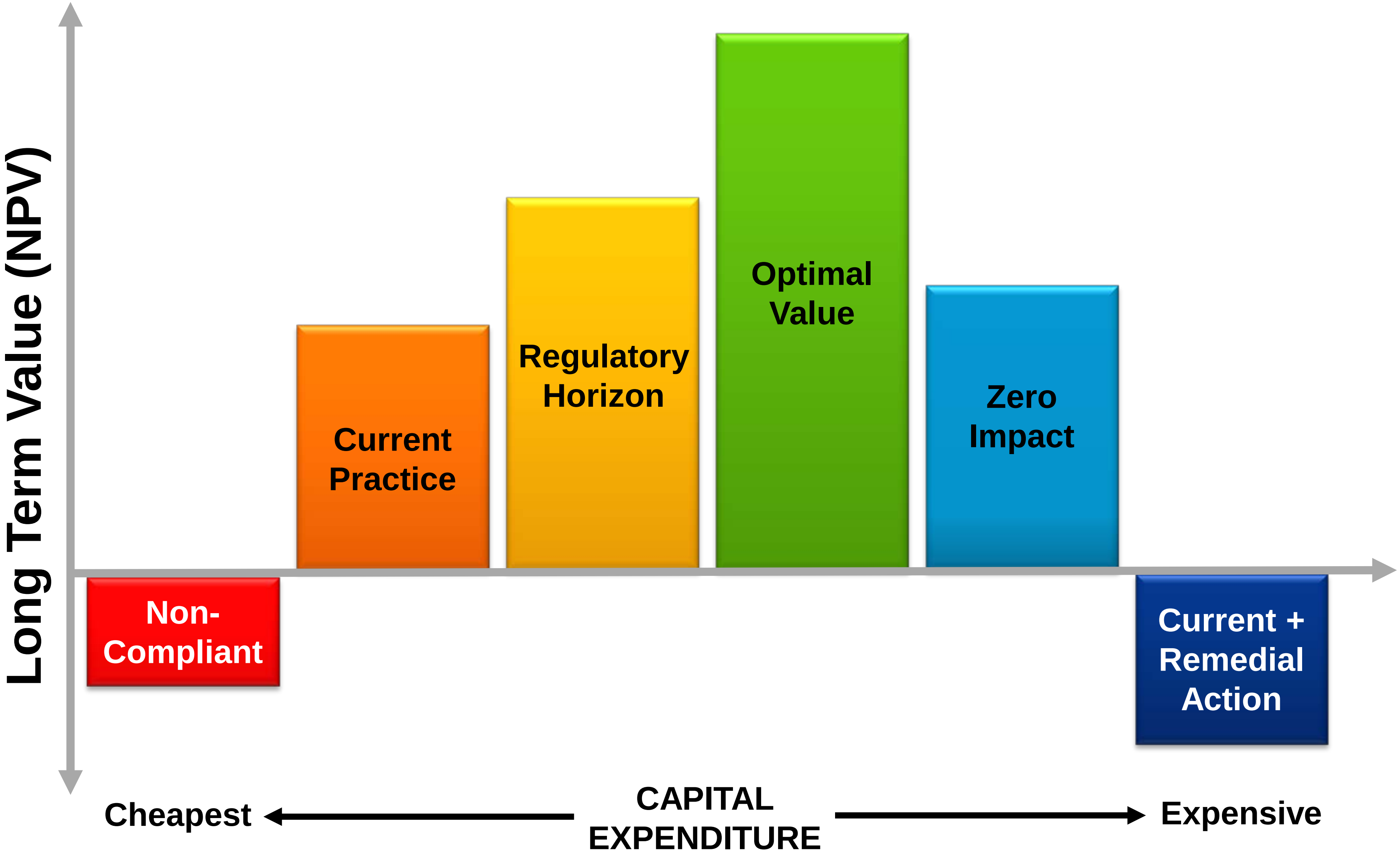
- Key features:
  - Identify and analyze relevant **financial** and **non-financial costs, benefits** and **risks** through monetization (NPV)
  - Adopt a **long term** perspective, to help **future-proof** projects against potential future risks (costs)
  - Utilize **dynamic sensitivity analysis** to evaluate and overcome uncertainties
  - Enables consideration of **environmental and social issues** in decision making
  - Produces **defensible results** based on reliable, objective methodologies and data
  - Process is designed to support a customer's **corporate sustainability goals**
  - Improved ability to **communicate value of action** to stakeholders, incl. regulators

Enhanced consideration of risk in decision making

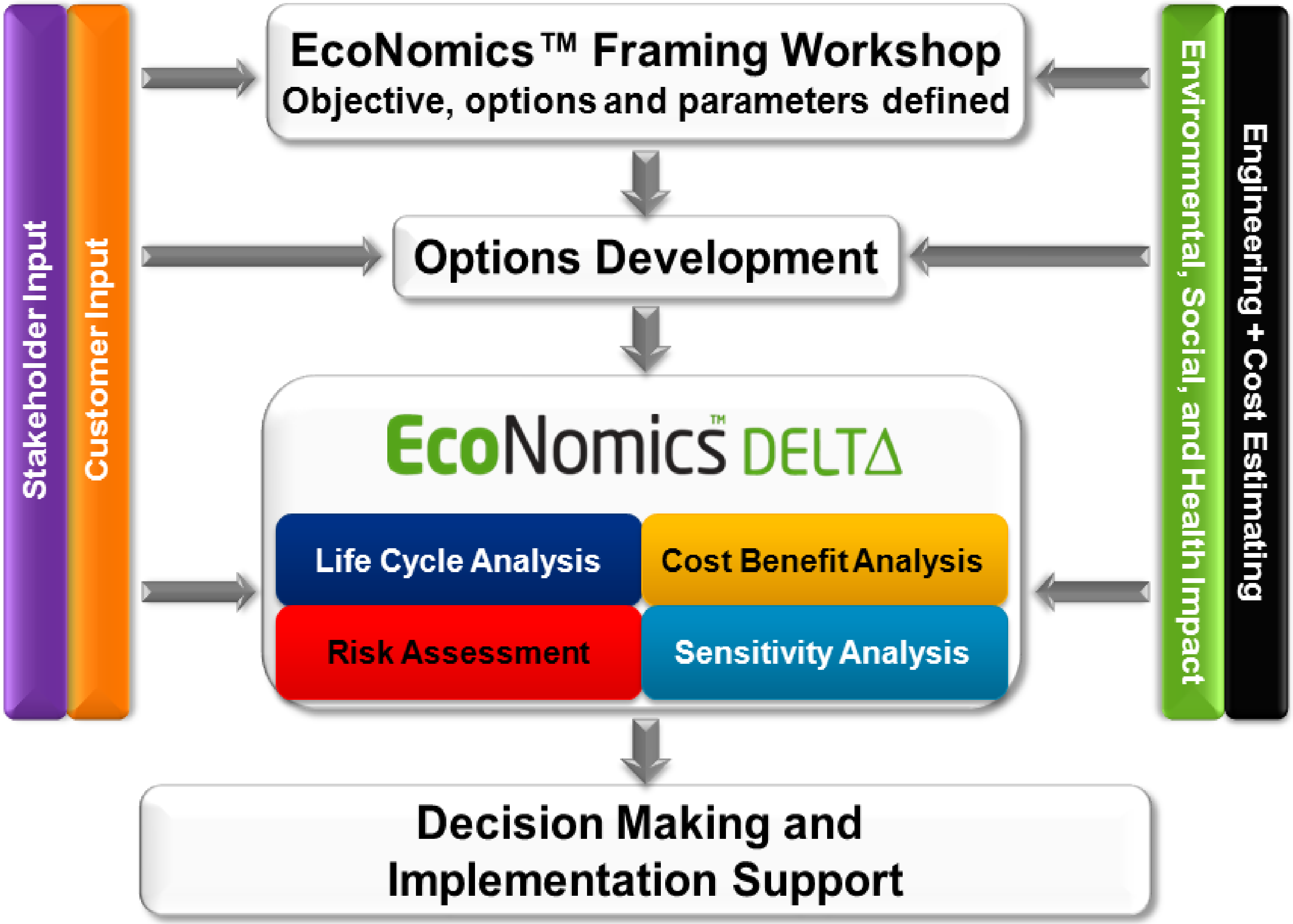


$$\mathrm{NPV} = \sum_{0}^{t} \left[\frac{\left(B_{financial} + B_{external}\right) - \left(C_{financial} + C_{external}\right)}{\left(1+i\right)^{t}} \right]$$

Identifies Optimum Value Solutions



Refined Process



LRQA Approved

CERTIFICATE OF APPROVAL

This is to certify that the Quality Management System of:

WorleyParsons Services Pty Ltd
Australia

has been approved by Lloyd's Register Quality Assurance Limited
to the following Quality Management System Standards:

AS/NZS ISO 9001:2008

The Quality Management System is applicable to:

Provision of EcoNomics™ Assessment services encompassing: scope framing, data collection, analysis and interpretation, using EcoNomics™ Assessment Process, including the DELTA toolset, as a basis for monetising the value of internal (project) and external (environmental and social) risk factors across asset lifecycle, allowing project options to be compared on a like for like dollar basis over a range of sustainability objectives and possible future conditions, to support decision-making.

Approval
Certificate No: 0942963/50

Original Approval: 09 March 2011

Current Certificate: 09 March 2011

Certificate Expiry: 30 September 2012

Issued by: Lloyd's Register Quality Assurance Limited

UKAS
001

This document is subject to the provision on the reverse
71 Fenchurch Street, London EC3M 4BS United Kingdom. Registration number 1879370

- Assessments are conducted according to a rigorous, gated process
  - Externally audited by Lloyd's Register Quality Assurance
  - Approved as a process under our ISO 9001 qualification
- EcoNomics"   DELT" software has been independently validated by IV&V

Burnt Timber 2

EcoNomics Assessment

Framing Workshop

- Framing Workshop held on August 21st, 2012
  - Agreed upon an Objective:

    To use a risk-based approach to optimize the economic, social and environmental considerations that measurably reduces Shell's long term liability and receives regulatory approval to an acceptable end point.

    - *Development of site characterization, selective remediation and reclamation approach for an example foothills site.*
    - *Create a paradigm conducive to evolving regulations and industry approaches to sustainable remediation and reclamation that enhances industry social license and facilitates public acceptance.*
  - Defined the options:
    - *Analysis of 15 options*
  - Defined the externalities to be examined and major assumptions.

Options Investigated

#	**Short Name**	**Description**
1	1_BAU	Business as Usual (BAU)
2	2_BAU+MNA	BAU with Monitored Natural Attenuation (MNA) for 25 years
3	3_X+Disp	Excavation and offsite disposal with groundwater monitoring for 2-5 years
4	4_SX+MNA	Selected excavation and offsite disposal with MNA for 25 years
5	5A_I-Sur 5B_I-CO 5C_I-Nut 5D_I-Com	Selected excavation and in-situ treatment with groundwater monitoring for 5-10 years a. Surfactant Flushing b. ISCO c. Nutrient Amendments d. Combination of three above
6	6A_E-Sur 6B_E-CO 6C_E-Nut 6D_E-Com 6E_E-Phy	Selected excavation and ex-situ treatment with groundwater monitoring for 2-5 years a. Surfactant Flushing b. ISCO c. Nutrient Amendments d. Combination of three above e. Phytoremediation
7	7_Encap	Onsite encapsulation with groundwater monitoring for 5-10 years, proven geotechnical stability
8	8_Cap	Cap sump in-place, recontour with groundwater monitoring for 5-10 years, proven geotechnical stability

Financial Components

- Capital Expense (CAPEX)
  - Onsite CAPEX – remediation, reclamation
  - Offsite CAPEX - haulage
- Non-energy Operating Expense (OPEX)
  - Fixed - Monitoring
- Energy OPEX
  - Diesel price
  - Gasoline price
- Saved OPEX
  - Administration Cost
- Other Financial Variables
  - Reputation
  - Workers Health and Safety
  - Spills
  - Road Damage

Financial Parameters and Assumptions

- **Administration Cost:** refers to the cost that Shell pays to maintain the site every year. Becomes a saved cost in options where closure is achieved.
- **Reputation:** possible costs incurred to Shell due to a public safety incident involving heavy vehicles transporting contaminant.
- **Workers' Health and Safety:** cost of an injury that could occur during onsite activities involving contractors and Shell personnel.
- **Spills:** refers to the cost of clean-up in case a spill were to happen on site**.**
- **Road Damage:** costs which Shell may be liable to pay for road damage repairs. caused by heavy vehicles. Cost was applied to the entire hauling route (154km), all roads were treated similarly i.e. gravel road, paved road, highway.

Summary of Financial Parameters

Financial Parameters	Unit (CAD$ 2012)	Base	Low	High	Source
Diesel price	$/L	$1.10	$0.50	$2.00	Current market price (Oct 2012)
Gasoline price	$/L	$1.13	$0.50	$2.00	Current market price (Oct 2012)
Administration Cost	$/year	$12,000	$12,000	$24,000	**Base:** Pers. Comm. Shell (October 2012) **High:** CPI Adjusted for 25 years.
Reputation	$/incident	$250,000	$0.00	$500,000	Pers. Comm. Shell (October 2012)
Workers' Health and Safety	$/injury	$26,010	$0	$5.4 mil	Zhang et. al. (2005)
Spills	$/incident	$5,000	$1,000	$100,000	Pers. Comm., WorleyParsons Contaminated Sites (October 2012)
Road Damage	$/heavy vehicle km	$2.00	$0.00	$5.00	Pers. Comm. Shell (October 2012)

External Components and Assumptions

- **Greenhouse Gases (GHG):** societal cost of climate change due to emissions related to vehicle fuel consumption (includes light and heavy vehicles or equipment).
- **NOx/SOx:** societal cost of air pollution due to emissions related to vehicle fuel consumption (includes light and heavy vehicles or equipment).
- **Public Nuisance:** societal cost of noise and congestion due to hauling trucks travelling from the site to the landfill.

  Only applicable to options where contaminated soil must be hauled to the landfill. Affected communities include Sundre, Caroline and Rocky Mountain. Total haul distance approx. 154 km, of which the haul distance through the communities is approx. 9 km.

External Components and Assumptions (cont'd)

- **Public Safety:** societal cost due to health and safety related accident risks from offsite contaminant haulage.
- **Iconic Species:** value of the societal loss associated with the risk of a grizzly bear strike and fatality due to hauling trucks travelling from the site to the landfill.
- **Ecological Services Value (ESV):** value of boreal forest land and its provision of atmospheric stabilization, carbon storage, water supply, raw materials, flood control, water filtering, biodiversity and other services.
- **Community Amenity Value (CAV):** value of boreal forest to the community for nature-related activities such as wildlife viewing, fishing, hunting and camping.

Summary of Economic Components

External Asset	Unit (CAD$ 2012)	Base	Low	High	Source
GHG	$/tonne	$15.00	$0	$100	Offsetters (2012), Stern (2007)
NOx	$/tonne	$13.41	$0	$2,400	U.S Energy Information Administration (2012), and Clean Air Conservancy (2010)
SOx	$/tonne	$1.79	$0	$1,500	U.S Energy Information Administration (2012), and Clean Air Conservancy (2010)
Public Nuisance	$/heavy vehicle km	$0.13	$0	$0.53	Litman (2009)
Public Safety	$/heavy vehicle km	$0.13	$0	$0.50	Litman (2009)
Iconic Species	$/incident	$20,000	$0	$927,000	Alberta Sustainable Resource Development (2008), Hill (1988), Alberta Tourism (2012)
Ecological Services Value	$/per ha/year	$979	$0	$1,523	Anielski and Wilson (2009)
Community Amenity Value	$/per ha/year	$24	$0	$2484	Anielski and Wilson (2009) WorleyParsons/Alberta Parks (2012)

General Model Assumptions

Parameter	Units	Base	Low	High	Explanation
Planning Horizon	years	25	--	--	Chosen in Framing Workshop
Financial Discount Rate	%	15%	3.5%	20%	Real, post tax rate provided by Shell. Threshold percentage interest rate value where the Net Present Value of benefits is equal to the Net Present Value of costs. The threshold value used to evaluate whether a given project/action should go ahead or not.
Social Discount Rate	%	3.5%	2%	10%	Peer-reviewed social discount rate applied to financial and economic variables. Lower than typical corporate rates, as high discount rates generally 'devalue the future', as benefits realised in future have greatly reduced present value.
Energy Escalation	%	2.0%	0%	10%	Rate of energy price escalation

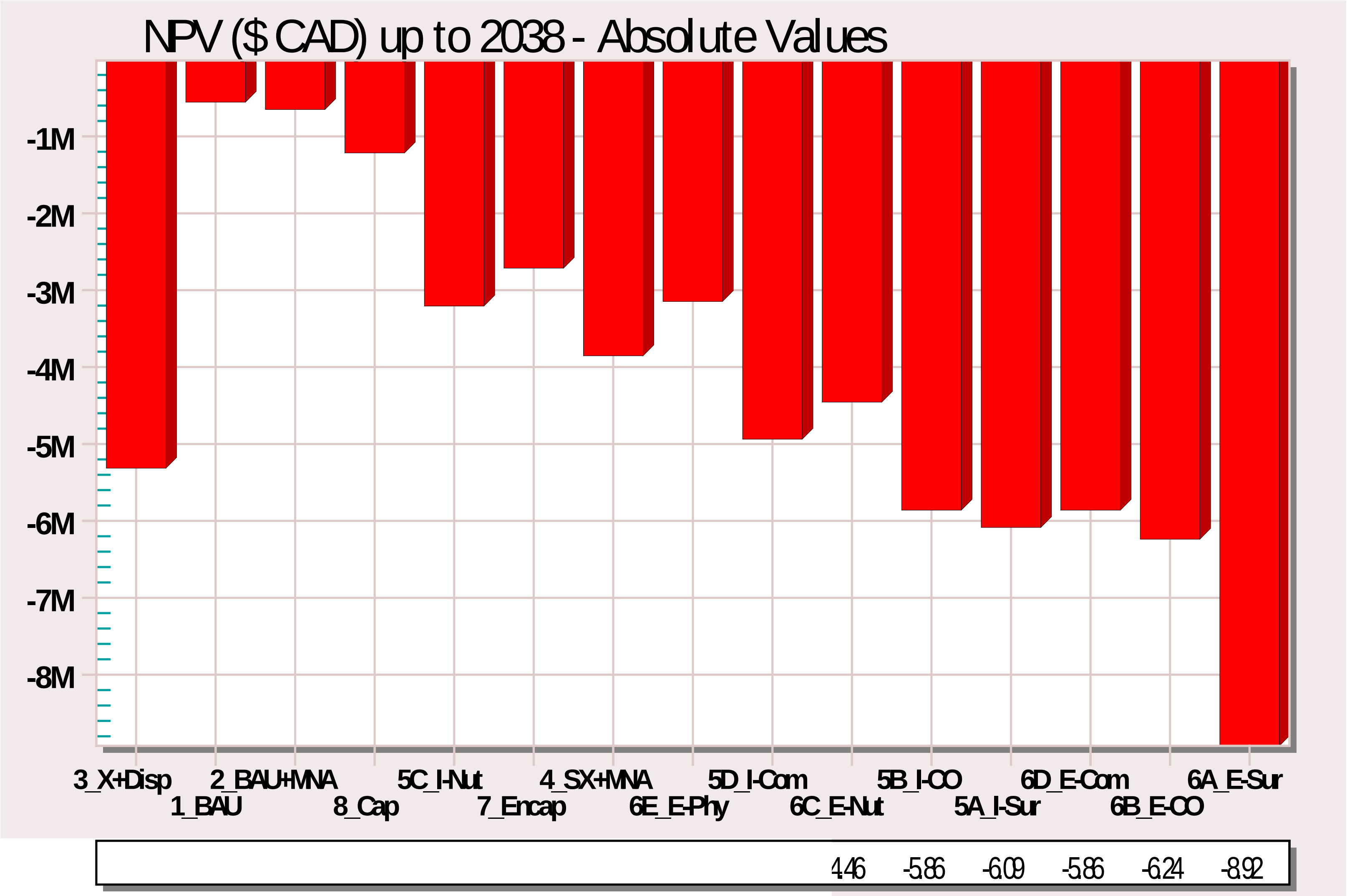
Limitations

- **Water**
  - Assumed remedial options will use minimal water and not impact groundwater or surface water bodies at/near the site. Consequently, water was not considered in this assessment. Only road watering included under financial cost.
- **By-products**
  - Assumed no significant concentrations of harmful by-products originated from remedial options.
- **Risk to GW and SW**
  - Groundwater and surface water contamination potential not considered in this assessment.
- **Volatilization of Hydrocarbons**
  - Volatilization of hydrocarbons has not been considered in this assessment. Preliminary investigation showed inconsequential impact to the model.
- **Primary Project Costs**
  - Only primary project components considered in this assessment, i.e. relatively large cost drivers.

Results – Financial (Internal)

Base Case

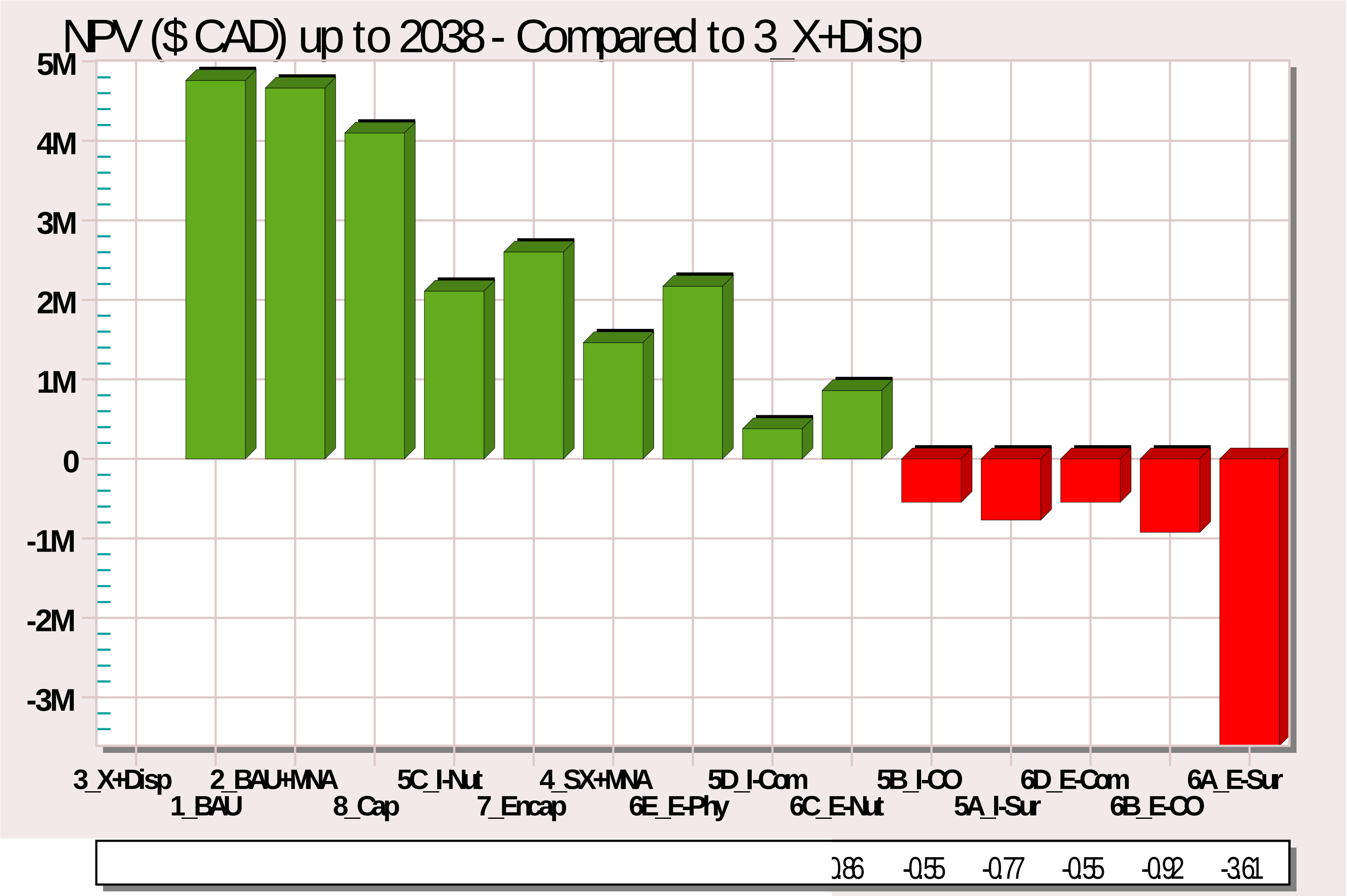
i = 15%



Results – Financial (Internal)

Base Case

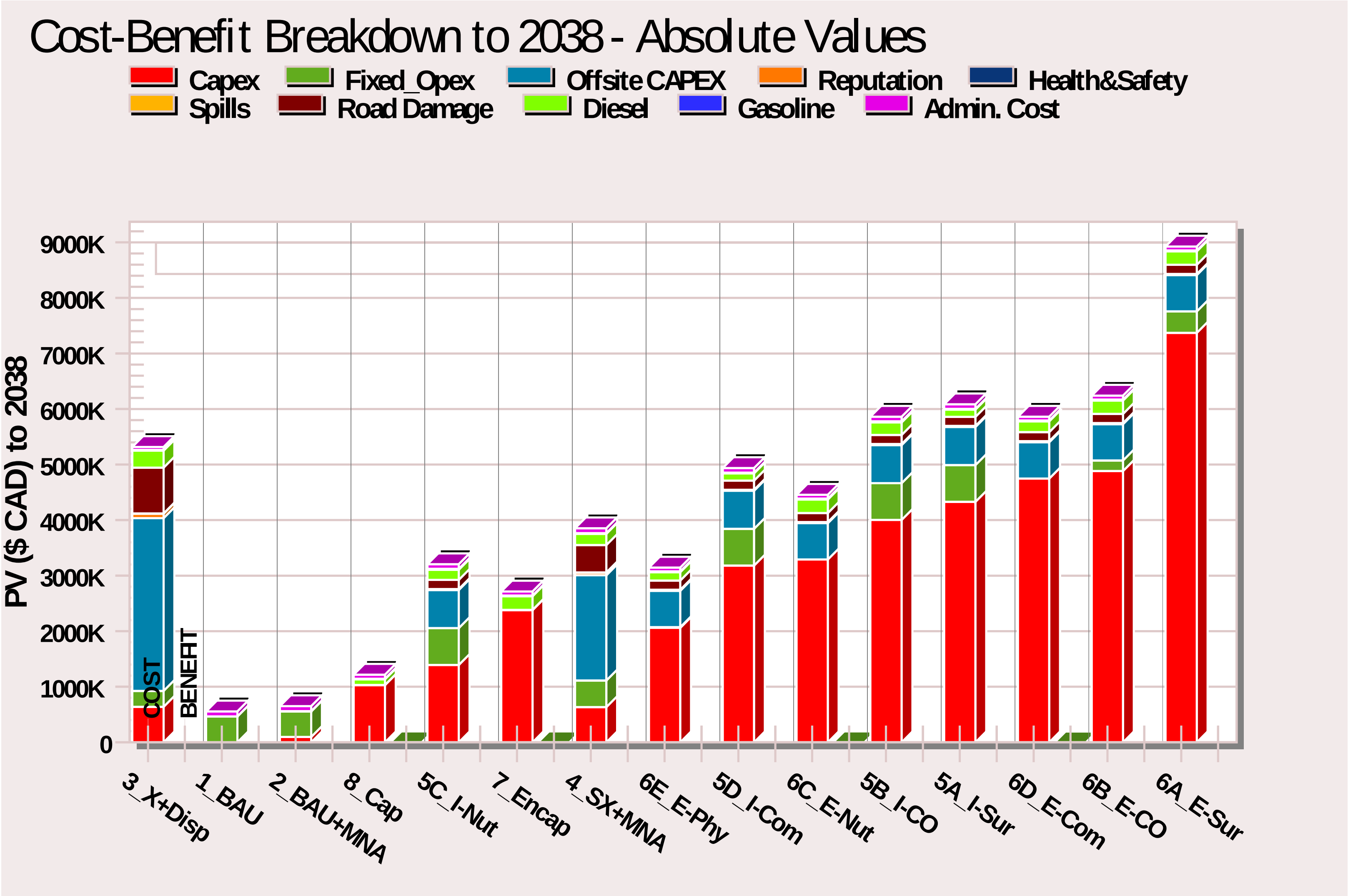
i = 15%



Results – Financial (Internal)

Base Case

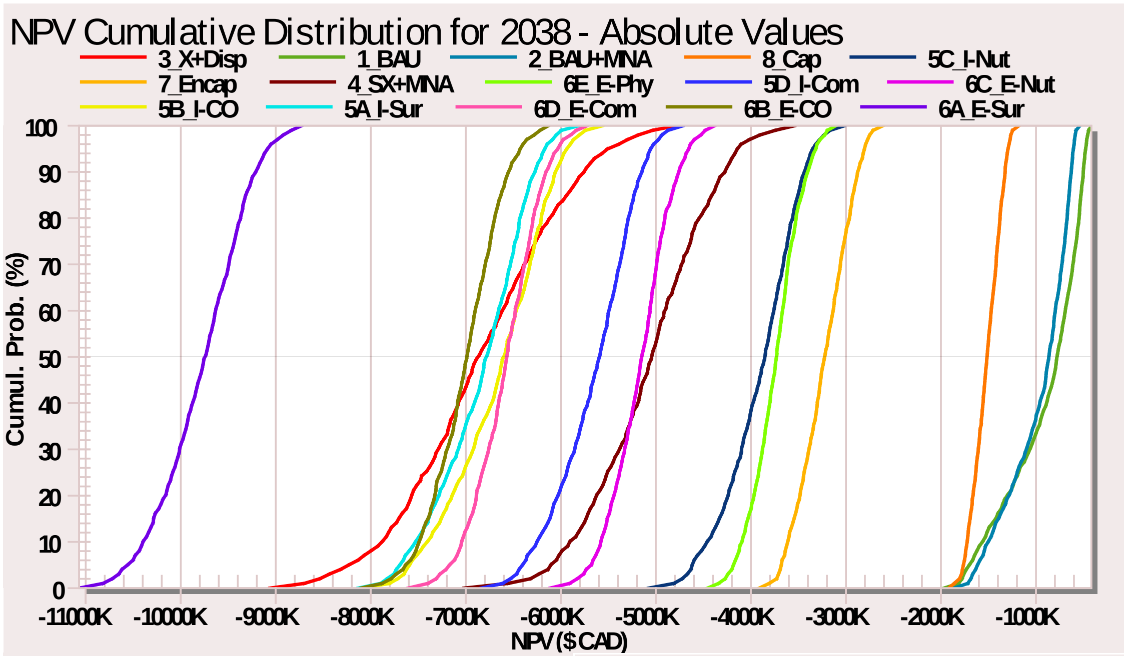
i = 15%

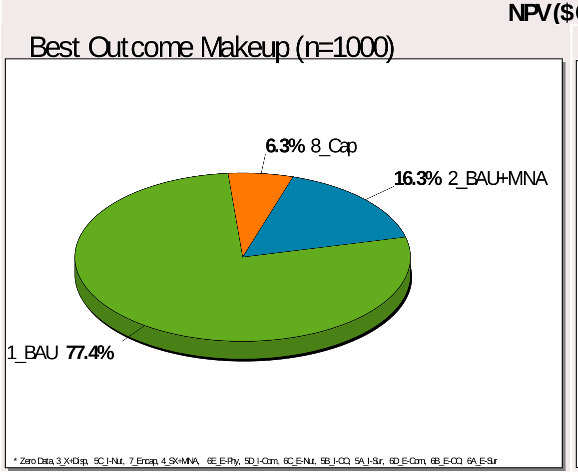


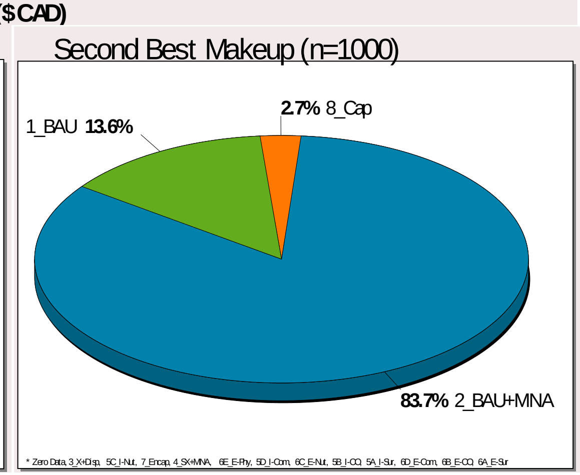
Cumulative Probability – Financial (Internal)

Base Case

i = 15%



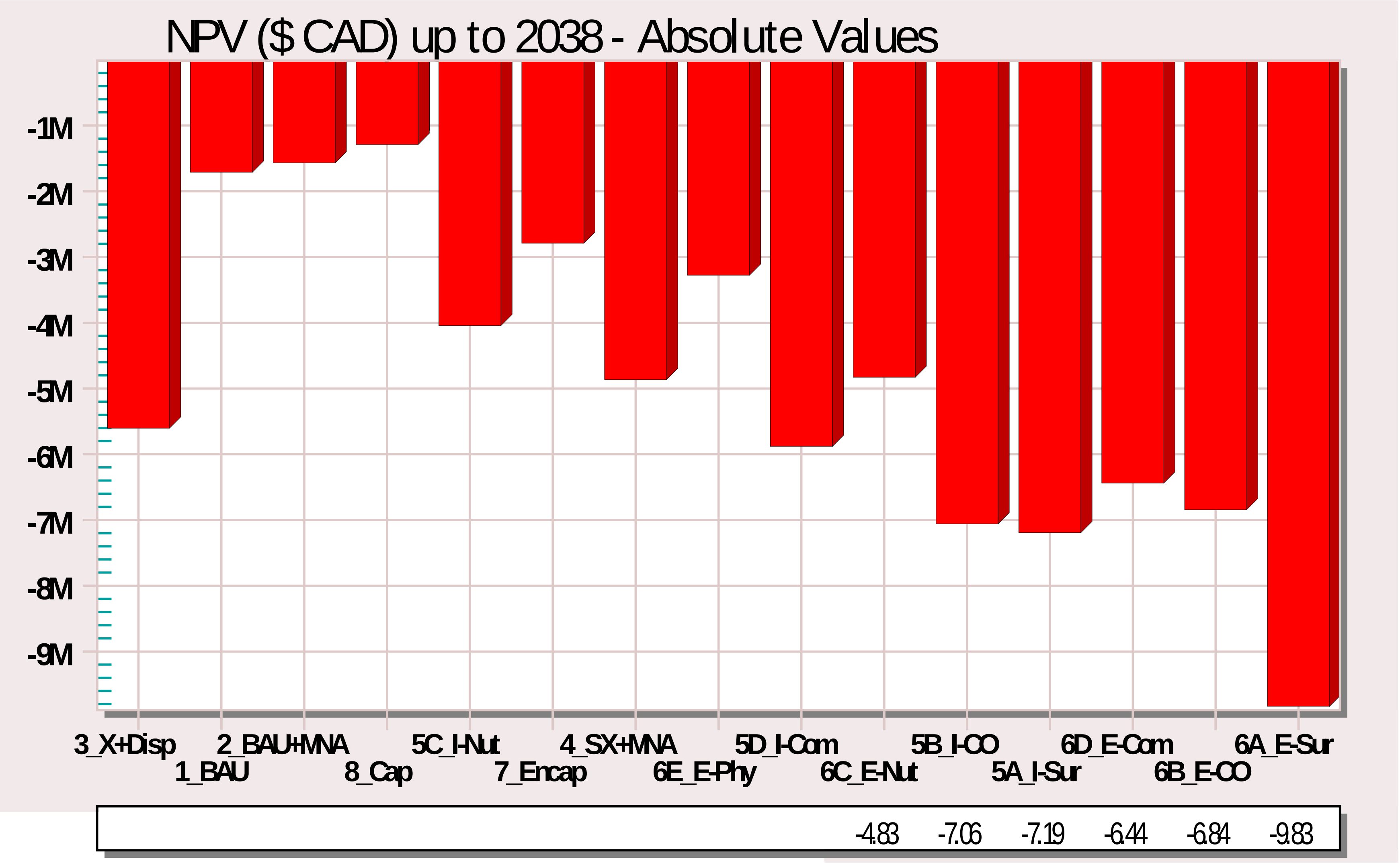




Results – Economic

Base Case

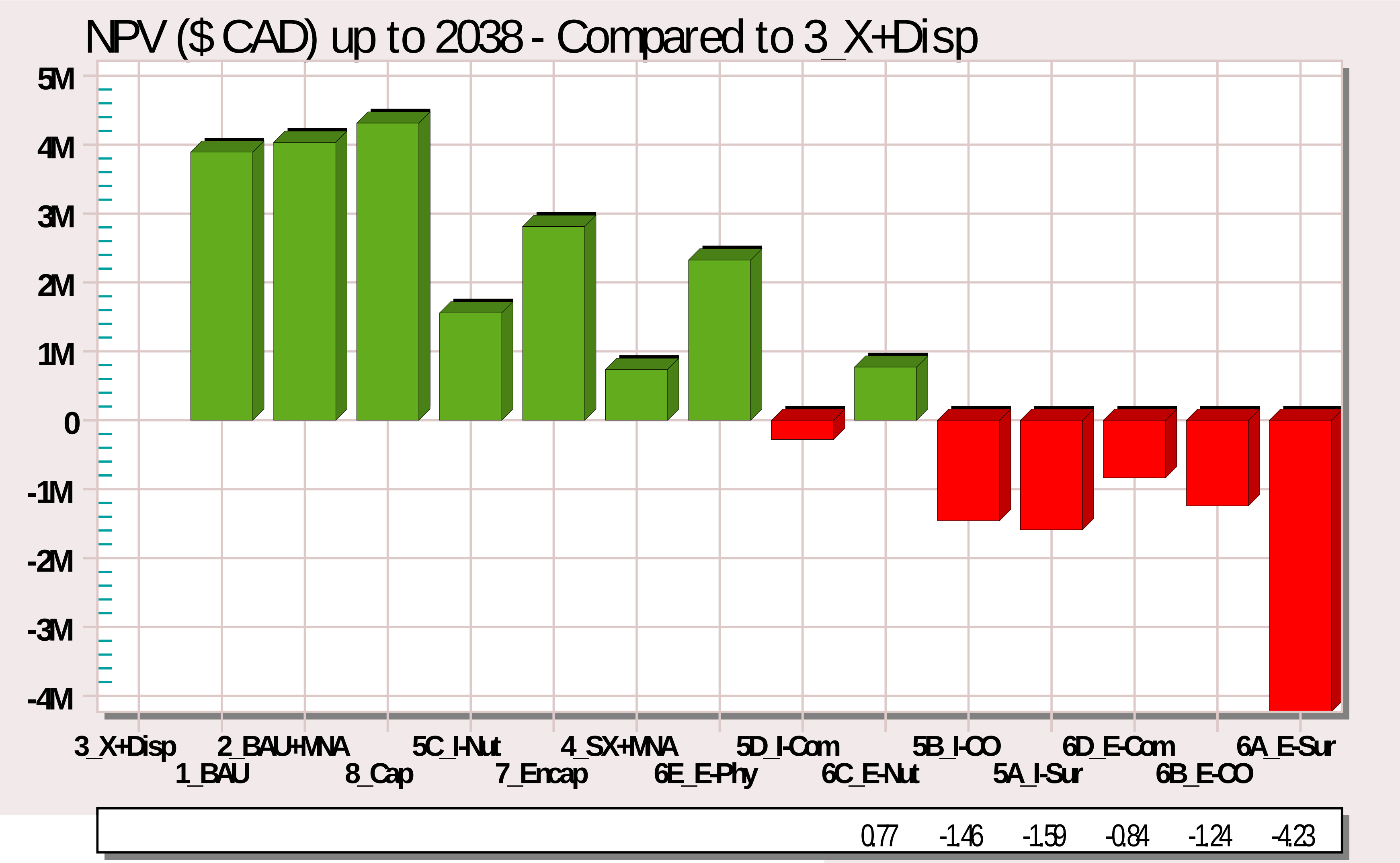
i = 3.5%



Results – Economic

Base Case

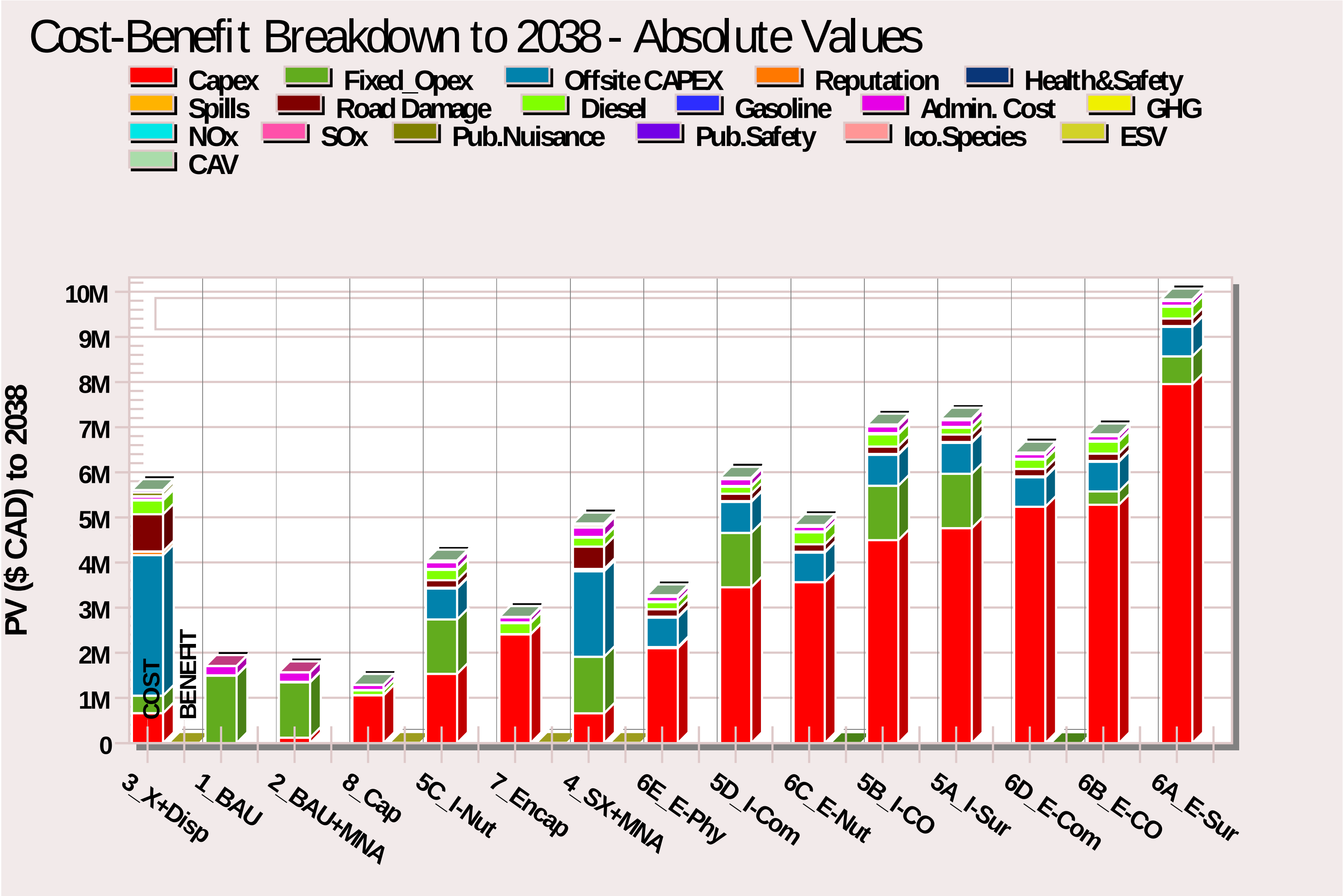
i = 3.5%



Results – Economic

Base Case

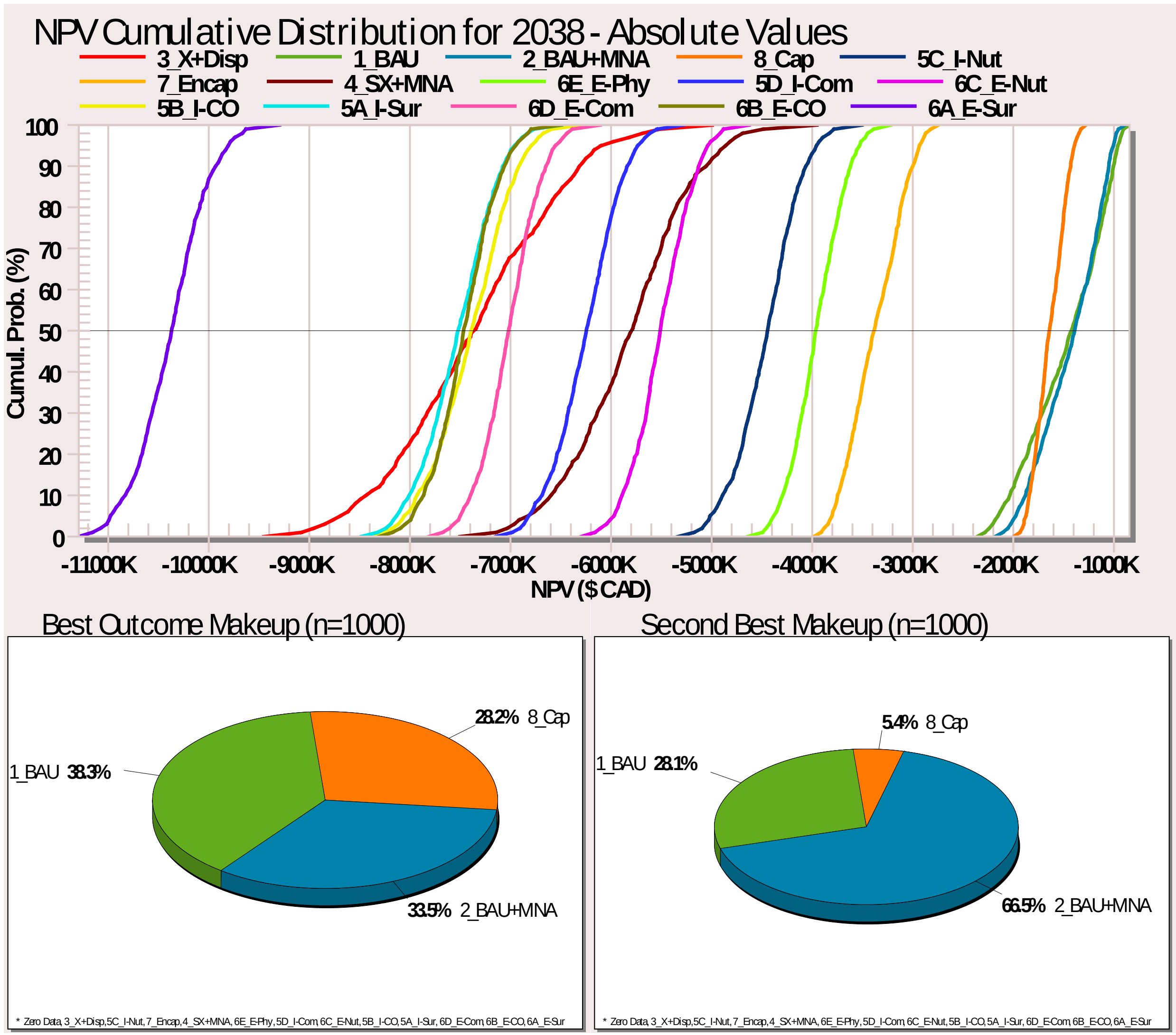
i = 3.5%



Cumulative Probability – Economic

Base Case

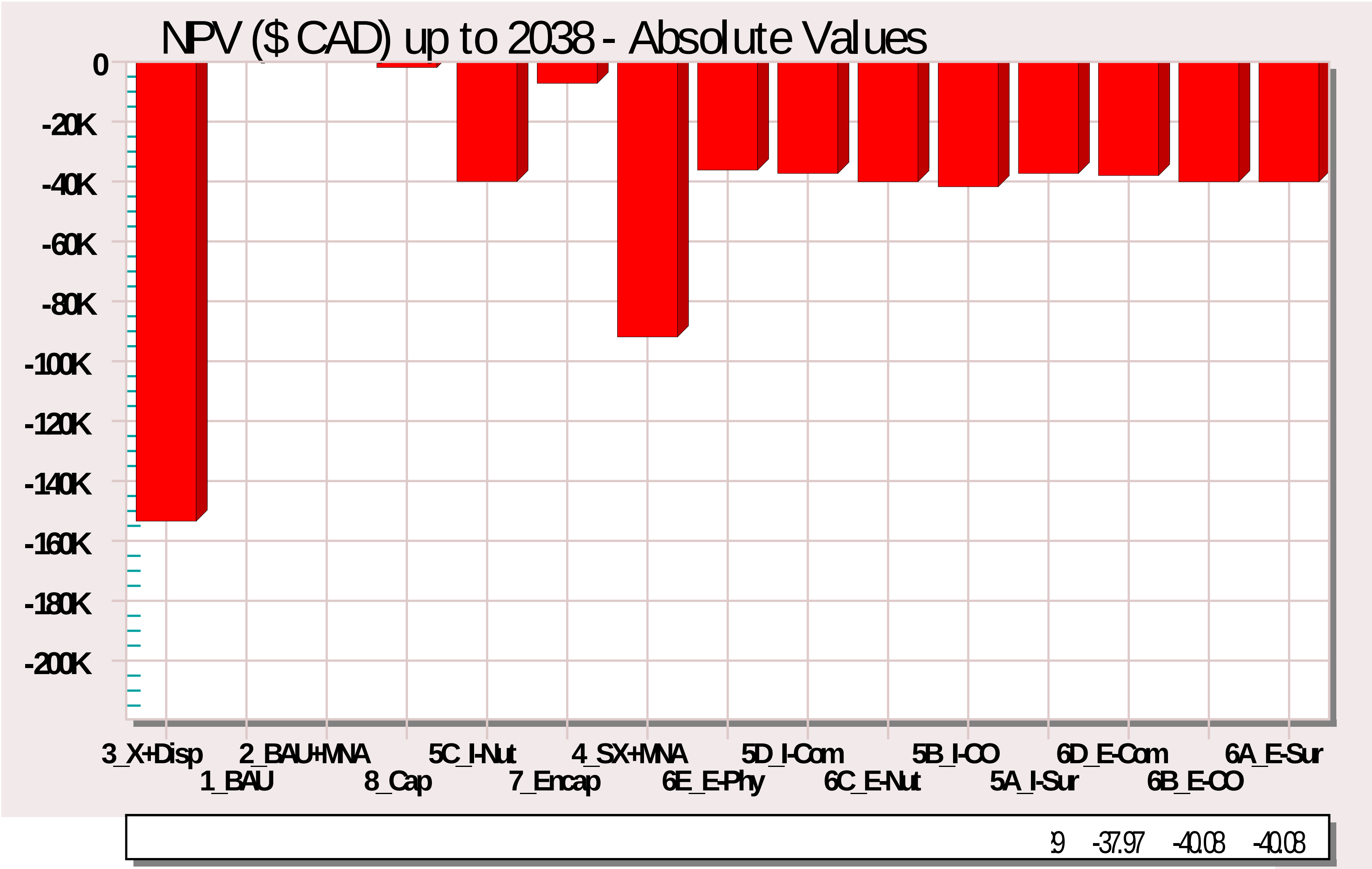
i = 3.5%



Results – Externalities Only

Base Case

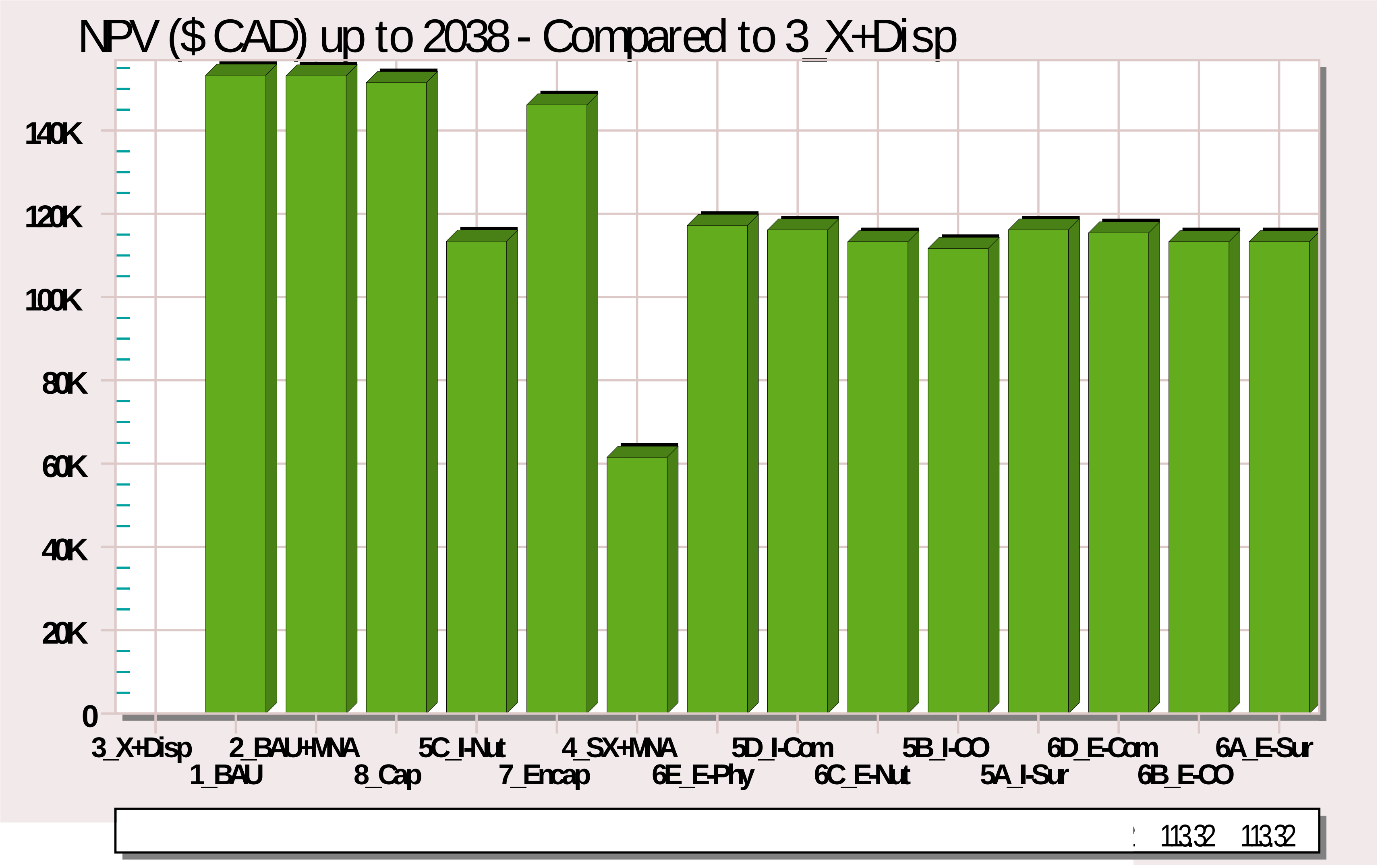
i = 3.5%



Results – Externalities Only

Base Case

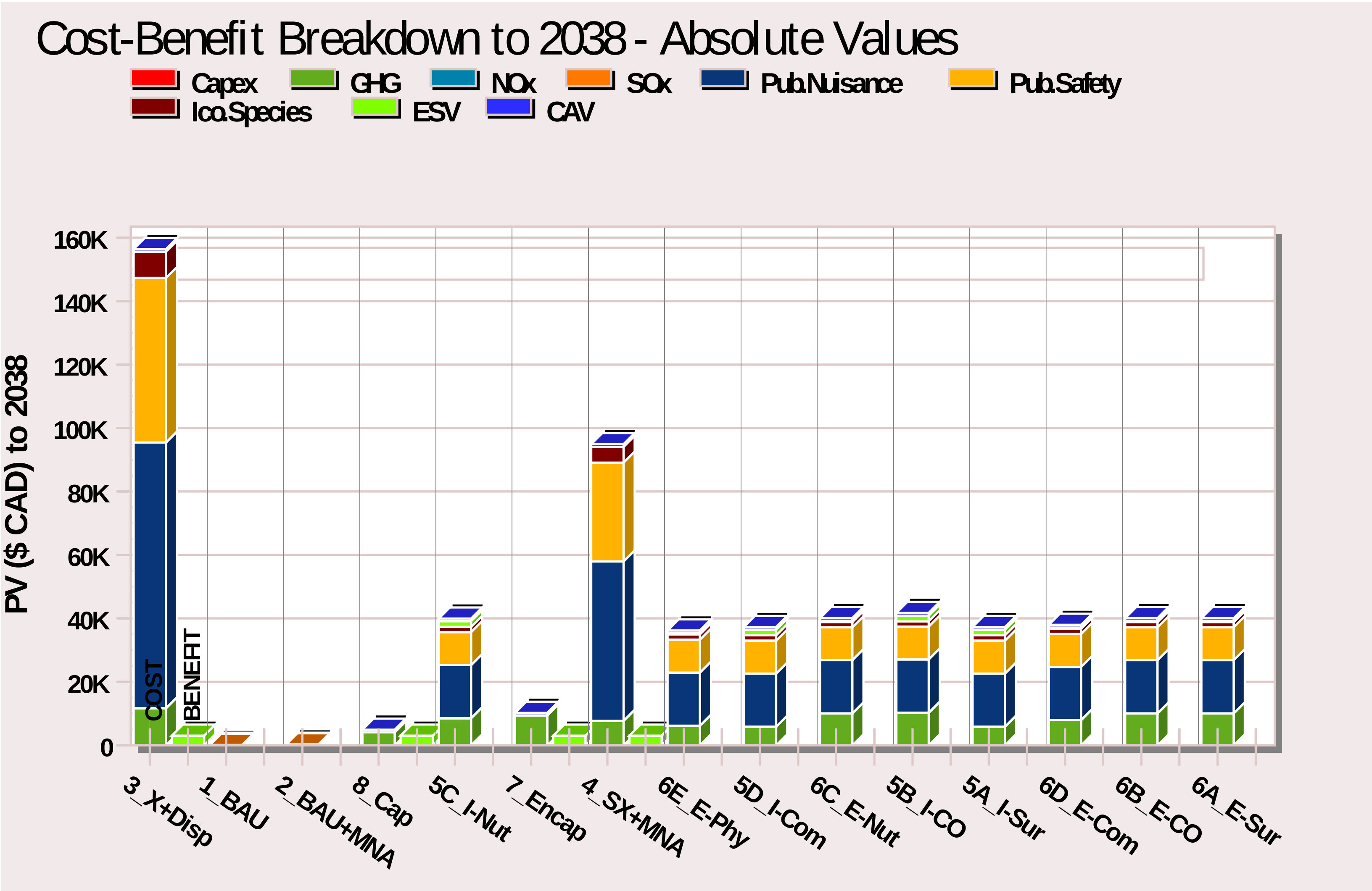
i = 3.5%



Results – Externalities Only

Base Case

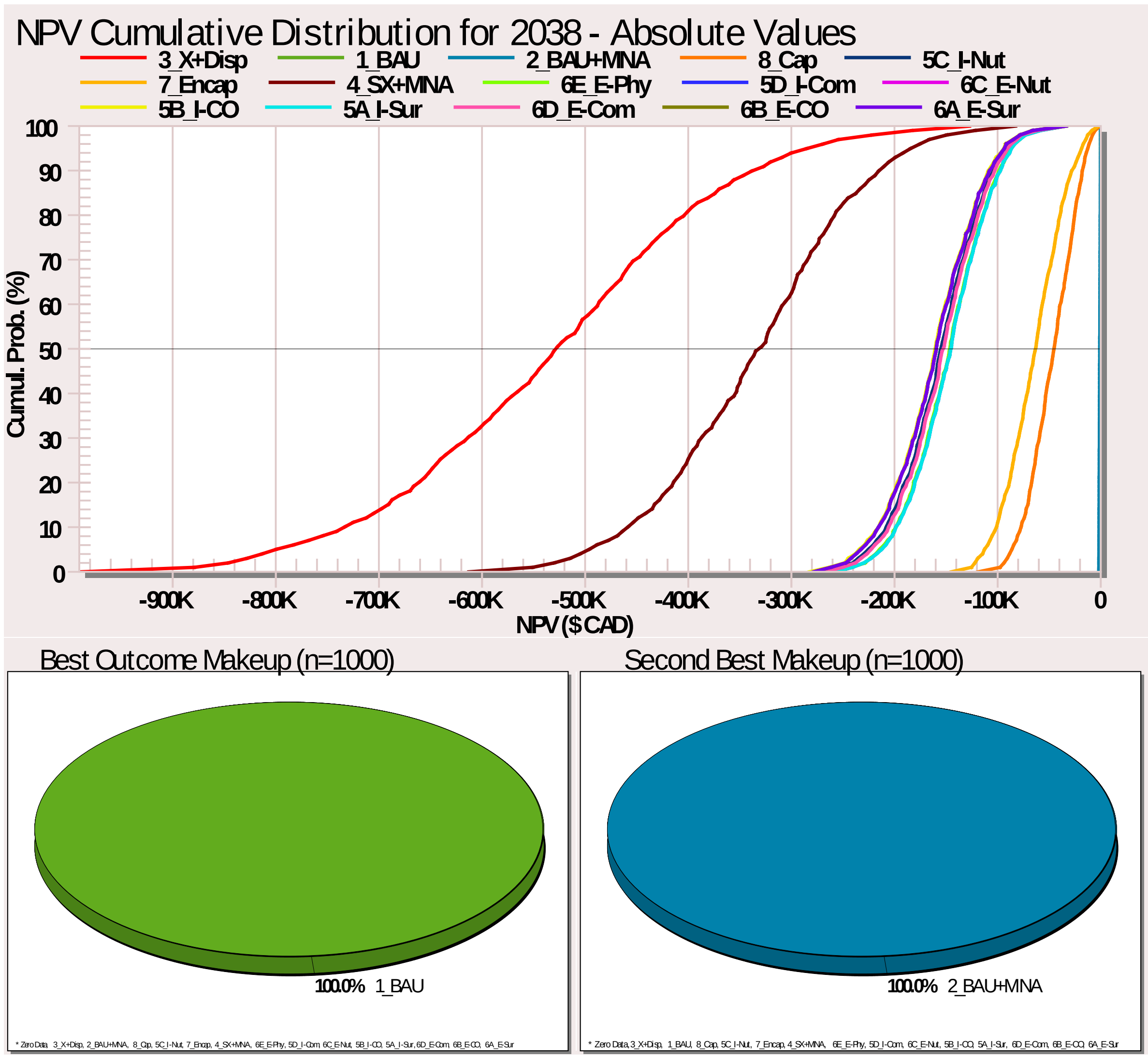
i = 3.5%



Cumulative Probability – Externalities Only

Base Case

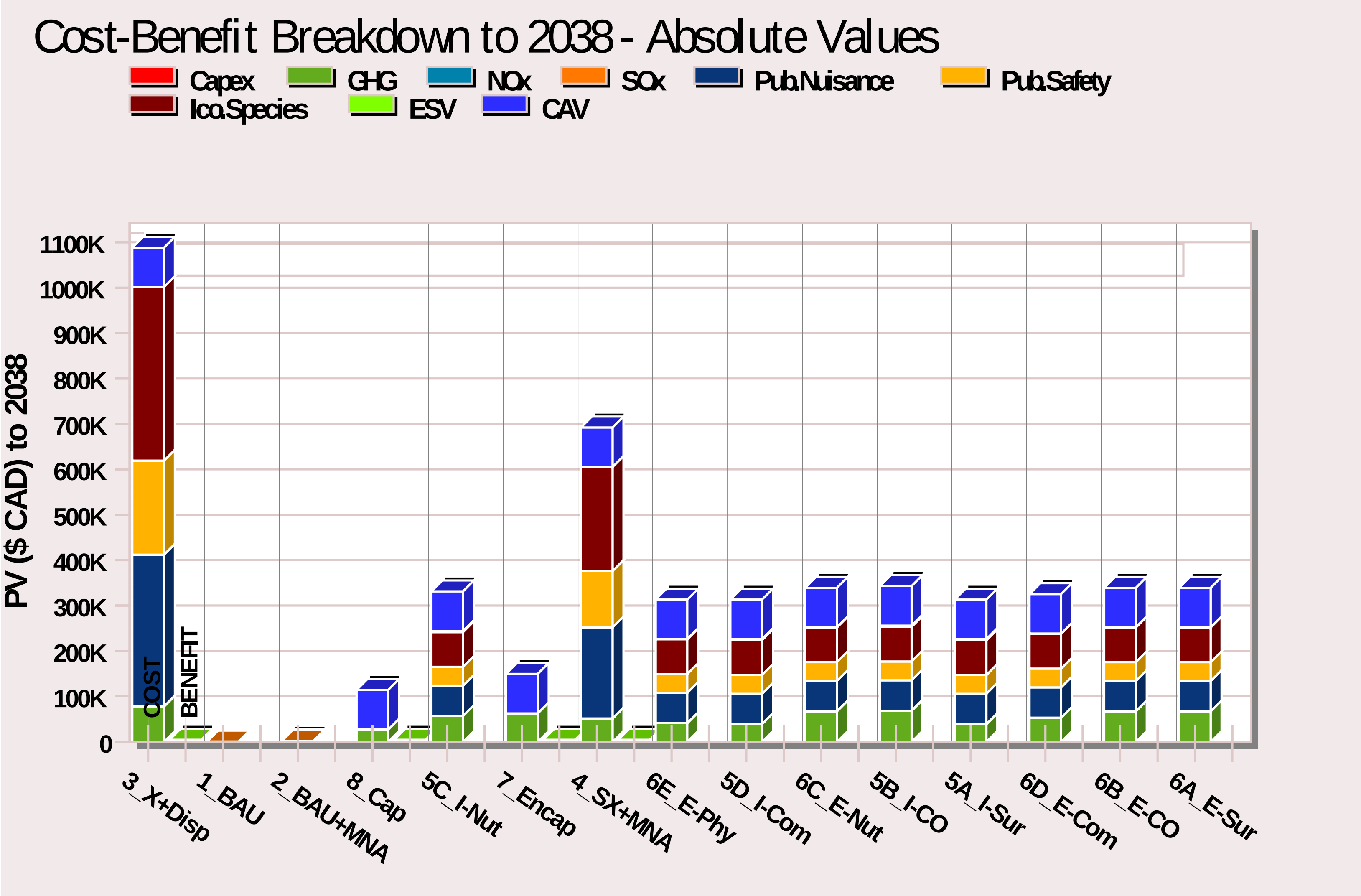
i = 3.5%



Results – Externalities Only

Social High Case

i = 3.5%



DELT” Presentation

Preliminary Conclusions & Considerations

- **Regulatory**
  - Excavation and placement of contaminated soils in a Class 2 land fill is currently the only means of securing a Reclamation Certificate (or regulatory release) from the site.
- **Financials**
  - Financially, the ‘Business As Usual’ scenarios of continued monitoring are the preferred options as they involve the lowest CAPEX and OPEX costs.
  - The ‘regulatory standard’ option of Excavation & Disposal (Option 3) performs poorly from a financial perspective.
- **EcoNomic**
  - Economically, the ‘Capping’ scenario is the preferred option as it involves a shorter period for capital and operating expenses compared to the ‘Business As Usual’ scenarios. It also take significant external risk out of the process owing to significantly fewer total equipment hours on-and off-site.
  - The ‘Excavation & Disposal’ scenario also performs poorly economically, owing to the transportation-driven capital expenditure and associated impacts to communities and surrounding environment.
  - Under an externality-only approach, the ‘Business As Usual’ and ‘Capping’ scenarios are the preferred options as they involve the lowest external costs.

Thank You

EcoNomics™

delivering profitable sustainability