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Port Stakeholder Perceptions of Sandy Impacts: A Case Study of Red Hook, New York

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10 **Abstract**

11 Understanding the impacts of coastal storm hazards on all maritime port system
12 stakeholders (e.g. operators, tenants, clients, workers, communities, governments) is essential to
13 comprehensive climate change resilience planning. While direct damages and indirect impacts
14 are quantifiable through economic data and modeling, qualitative data on the intangible
15 consequences of storms are necessary to explicate interdependencies between stakeholders as
16 well as conditions that substantially affect response and recovery capacities. This case study
17 explores Hurricane Sandy storm impacts using evidence solicited from stakeholder
18 representatives and extracted from contemporaneous and technical accounts of storm impacts on
19 the port system at Red Hook Container Terminal, Brooklyn, New York, USA. Results highlight
20 the wide range of direct damages, indirect costs, and intangible consequences impacting
21 stakeholders across institutional boundaries and requiring coordination for recovery, providing
22 insight into stakeholder relationships and dependencies in the post-disaster response and
23 recovery process that are often not fully accounted for in current vulnerability assessment and
24 response planning methodologies.

25 **KEYWORDS:** resilience planning, disaster recovery, externalized costs

26 **1. Introduction**

27 Maritime ports are critical to the national transportation infrastructure, providing access
28 to an oceangoing international trade network which accounts for more than 80% of the global
29 trade by volume, including critical imports ranging from vehicles and raw materials to food and
30 medical supplies (UNCTAD 2018). Securing the resilience of the national port infrastructure is
31 a primary economic and defense priority, necessitating robust resilience planning (CMTS 2017).
32 However, ports are inherently exposed to significant risk of harm from coastal storm impacts,

33 because they must operate at the vulnerable land-sea interface where wind, flood, and storm
34 surge impacts are concentrated (Ng et al. 2016). As climate change leads to rising sea levels and
35 intensified storm impacts in many parts of the globe (Melillo et al. 2014), ports must account for
36 and adapt to these changes over both mid- and long-term planning horizons (Becker et al. 2018;
37 USDOT 2014; EPA 2008).

38 The port stakeholder cluster (De Langan 2004) includes port owners and operators;
39 tenants, shippers, and other port clients; government regulators responsible for the safety and
40 economic vitality of the national port system; and surrounding communities which depend on
41 ports for access to the global economy and for employment (Ward 2001; Becker et al. 2013).
42 Different port stakeholders play different roles in the port's resilience decision-making, including
43 through direct planning (in the case of internal stakeholders such as owners and operators) and
44 through external economic or political influence (Zhang et al. 2017; Freeman 2010, Bryson
45 2004). In turn, different stakeholders bear the harms and costs of storm impacts to port
46 operations differently as well. In some cases, the harms of a storm impact may not only affect a
47 stakeholder that is directly damaged (e.g., a port operator that must repair damaged cranes), but
48 may also be externalized to other stakeholders throughout the cluster that are do not have direct
49 responsibility or capacity for repairing the damage, but that nevertheless depend on its recovery
50 to resume normal operations (e.g., a shipper that must reroute cargo and defray lost revenue).
51 These externalized harms propagate throughout the stakeholder cluster according to a network of
52 economic and institutional inter-reliance among stakeholders that is not always necessarily fully
53 accounted for or engaged by planning processes (Zhang et al. 2017; Becker et al. 2014; Messner
54 et al. 2015).

55 A robust understanding of how all harms and costs of storm impacts are either
56 internalized or else propagated throughout the stakeholder cluster is critical to achieve proactive,
57 comprehensive resilience planning (Messner et al. 2015). So too is an understanding of how
58 those impacts function differently in different ports according to each port's unique
59 circumstances (Becker et al. 2014). Identifying port-specific impacts is a first step toward
60 identifying and deciding between resilience strategies. However, impact assessment methods
61 often do not allow for a detailed understanding of how storm impacts might have differential
62 effects on different components of the stakeholder cluster, whether because the scale of analysis
63 is too broad to capture effects on individual stakeholders (Lian et al. 2007; Hallegatte 2008), or
64 because the scope of analysis is constrained to particular quantifiable impacts, such as insured
65 losses (Grossi et al. 2005) or direct damage to structures (Curtis 2007; LADOT 2006). Because
66 impacts may propagate through the stakeholder cluster as indirect or intangible impacts, not only
67 quantitative but also qualitative data are necessary to comprehensively characterize storm
68 impacts on a port. There is a need for improved integration of qualitative impact data with the
69 quantitative impact modelling and data used in the vulnerability assessment methods that provide
70 the basis for resilience planning and decision making (Aerts et al. 2018; Stempel et al. 2018;
71 Becker et al. 2014; Di Baldassarre et al. 2015). This paper contributes to the field of port policy
72 and management through a theory-based analysis of stakeholders' perceptions. The cascading
73 impacts resulting from hurricanes have economic, social, and environmental effects on numerous
74 stakeholders throughout a port system. These cascading consequences are still not well
75 understood, nor are they properly accounted for in current port planning practice.

76 This case study builds on work conducted by Becker et al in the ports of Gulfport,
77 Mississippi, USA and Providence, Rhode Island, USA, and seeks to expand and improve the

78 information available to decision-makers regarding coastal storm impacts for ports confronting
79 key policy decisions in resilience planning (Becker et al. 2014). There is a rich literature
80 describing the value of the case study approach, especially in emerging areas such as climate
81 adaptation and resilience. As Yin states, “The distinctive need for a case-study approach arises
82 out of the desire to understand complex social phenomena” (2008). And, as further elaborated by
83 Flyvbjerg, “a scientific discipline without a large number of thoroughly executed case studies is
84 a discipline without systematic production of exemplars, and a discipline without exemplars is an
85 ineffective one” (2006).

86 The subject of this case study is the Red Hook Container Terminal (RHCT; the Terminal)
87 in Brooklyn, New York City, New York, USA, a small cargo port in the Port of New York and
88 New Jersey. In October 2012, New York City suffered extensive damage and disruption from
89 Hurricane Sandy. Through targeted interviews with representatives of internal and external
90 stakeholder institutions, as well as assessment of reports on storm impacts to the Port, the case
91 study catalogs stakeholder perceptions of the direct, indirect, and intangible impacts of that
92 major coastal storm on the RHCT stakeholder cluster. Applying the methods used to analyze
93 storm impacts for the ports of Gulfport and Providence in Becker et al. (2014) also allows
94 comparison to the results from those other cities in different regions. The case of RHCT provides
95 insight into the propagation of storm impacts through a dense urban port stakeholder cluster,
96 provides empirical support for a typology of such impacts, identifies nontrivial and non-obvious
97 interdependencies, and contributes to a growing body of evidence that provides the foundation of
98 a nascent area of theory with direct practical applications to port management and policy.

99 **2. Description of Red Hook Container Terminal**

100 RHCT is a small port facility in the Port of New York and New Jersey, located one mile
101 south of the Brooklyn Bridge along Buttermilk Channel (Figure 1). It is the only terminal in
102 Brooklyn that serves container ships, handling 55,000 containers in 2016. RHCT handles
103 container, break-bulk, ro-ro, and project cargo, transferring goods to trucks for local delivery
104 throughout Brooklyn and Long Island, as well as for longer highway hauls (Red Hook Terminals
105 2019). Regular services include a CMA CGM round-the-world route that delivers Heineken beer
106 from Europe, and a Seaboard service from the Caribbean and South America carrying bananas.
107 The Terminal also hosts a container barge service across the Upper Bay to Port
108 Newark/Elizabeth, adding an additional 20,000 containers to its annual throughput (Red Hook
109 Terminals 2019).

110 *Insert Figure 1 – map of Brooklyn and map of terminals about here*

111 The Port Authority of New York and New Jersey (PANYNJ) own the terminal, including
112 four piers and administrative facilities, and Red Hook Terminals LLC operates the facility. The
113 PANYNJ Maritime Commerce Department sets building codes and provides engineering
114 management for capital projects, but does not participate in day-to-day operations. There has
115 been some form of cargo terminal on the site since the 1840's, and for most of that time,
116 maritime commerce drove the development of the surrounding Red Hook community.

117 Sandy made landfall in Brooklyn on Monday, October 29, 2012 as a post-tropical
118 cyclone. A great deal of the Red Hook neighborhood south and east of the Terminal is built on
119 reclaimed land with very little topographic relief. The combined high tide and storm surge struck
120 low-lying Red Hook with an 11.2ft storm tide, causing an estimated 4.1ft of inundation
121 throughout most of the community (Blake et al. 2013). Because the Terminal naturally slopes

122 down toward the water, inundation depths were even more severe in seaward parts of the facility;
123 tenants at RHCT's Pier 7 reported almost 5ft of water in their warehouse. Throughout New York
124 City, 44 deaths were directly attributable to the storm (Jaffe et al. 2015).

125 The U.S. Coast Guard (USCG) closed New York Harbor waterways and ordered the
126 evacuation of all vessels the day before the storm's arrival, pursuant to the Heavy Weather Plan
127 developed in collaboration with port stakeholders after Hurricanes Earl in 2010 and Irene in
128 2011. The Port remained closed after the storm until the USCG, in collaboration with the
129 National Oceanographic and Atmospheric Administration (NOAA), U.S. Geological Survey
130 (USGS), and Sandy Hook Pilots, could survey all waterways for obstructions to navigation,
131 pollution, and shoaling from storm tides. Extended power outages and fuel shortages on land
132 impacted the city for more than a week following the storm; this was compounded by
133 temperatures dropping below freezing, stranding many residents without heat, power, or
134 transportation in icy, slushy conditions. Although the USCG was able to progressively open
135 waterways to municipal sewage scows, then fuel barges, then more traffic over the following
136 days, the fuel terminals which processed and received home heating oil, diesel, and gasoline
137 remained crippled by the power outage, prolonging the fuel shortage even after the Port resumed
138 operation. RHCT received its first cargo vessel on November 6, eight days after the storm.

139 **3. Methods**

140 This case study was designed to provide qualitative and quantitative storm impact
141 information that is useful to planners and decision-makers with responsibility for implementing
142 resilience plans and policies in U.S. and international ports (Becker et al. 2014). In order to
143 comprehensively capture the range of impacts to the full RHCT stakeholder cluster, 'impact' is
144 defined broadly to encompass the full range of direct damages, indirect costs, and intangible

145 consequences (IPCC 2012) which result from a major storm and which meaningfully disrupt the
146 ability of a stakeholder to engage in normal operations. Direct damages are impacts with discrete
147 costs, which are incurred by the action of flooding, wind, or waves on port facilities, equipment,
148 and contents. Indirect costs to port stakeholder clusters are disruptions to the normal flow of
149 goods and services caused by direct damages or by efforts to recover from them. Direct damages
150 and indirect costs are impacts on the port as an economic system that can be expressed in terms
151 of value lost to one or more stakeholders from the baseline of normal economic conditions.
152 Intangible consequences for port stakeholder clusters encompass the range of impacts that are
153 substantively significant and relevant to stakeholder decision-making but nevertheless are poorly
154 described by economic valuation, such as loss of life, health impairments, or damage to the
155 environment or to cultural heritage.

156 For the purposes of this research, the RHCT stakeholder cluster is defined broadly to
157 include both internal and external stakeholders with an economic or institutional interest in the
158 successful normal operation of the Terminal (Becker et al. 2014). Internal stakeholders include
159 port owners (PANYNJ) and operators (Red Hook Terminals LLC). External stakeholders include
160 economic stakeholders (stakeholders with interests defined through contractual relationships, e.g.
161 tenants, shippers, insurers), public policy stakeholders (government institutions with
162 jurisdictional responsibilities for the port, e.g. USCG, Department of Transportation, state and
163 city agencies), community stakeholders (residents and institutions representing the cultural and
164 economic interests of hinterland communities, e.g. Community Boards, environmental groups),
165 and academic stakeholders (institutions which generate information or scholarship relevant to
166 port decision-making).

167 The study was designed to elicit two related kinds of information: comprehensive
168 cataloging of storm impacts to RHCT stakeholders, and identification of which stakeholder
169 group(s) (internal, economic/contractual, public policy, and/or community) carried the ‘burden
170 of recovery’ for each impact. The burden of recovery is defined broadly to encompass the
171 investment of financial, human, and institutional resources (i.e., time, effort, and expense) in
172 recovering from an impact; it is sensitive to stakeholders’ perceptions of their own and other
173 stakeholders’ capacity (e.g. technically, financially) and responsibility or authority (e.g. legally,
174 politically) to undertake such recovery activities.

175 The burden of recovery may be borne internally, or it may be externalized to other
176 members of the stakeholder cluster. In the case of direct damages, the burden of recovery is
177 generally borne internally by stakeholder institutions (Becker et al., 2014). For example, a tenant
178 may write off the loss of water-damaged products from its warehouse, or the port operator may
179 pay for replacement electrical equipment using an insurance payout. In the case of indirect costs,
180 economic losses can often become externalized and may not be ‘paid for’ by any one stakeholder
181 institution, but nevertheless may require the time and effort of one or more stakeholder
182 institutions to recover from. For example, the economic impact of damage to USCG aids to
183 navigation is felt by all economic stakeholders because of the disruption to vessel traffic until the
184 waterway is reopened. In that example, the burden of paying for repairs to the navigation aids
185 falls to the USCG (and, by extension, the federal taxpayer). In the case of intangible
186 consequences, some impacts are articulated broadly as an impairment of response capacity (e.g.,
187 the challenge of learning new disaster recovery procedures on the fly), while others can be
188 solved by the explicit efforts of particular stakeholder institutions (e.g., debris which blocks

189 roads and impedes repair efforts for stakeholders across the cluster, but which must be addressed
190 by the cleanup efforts of particular stakeholders, such as the city government or landowner).

191 Many of these indirect and intangible harms are externalized throughout the stakeholder
192 cluster. For the purposes of recording and analyzing results, each impact was classified
193 according to the stakeholder who held the burden of recovery only as perceived by the sources.

194 Data were gathered from two types of sources: interviews with port stakeholders and
195 contemporaneous news and retrospective technical reports addressing port damage from the
196 storm. Interviewees were identified through personal contacts, internet research, and referral by
197 other participants. In total, five port stakeholders were interviewed: two representatives of
198 PANYNJ, two representatives of USCG, and one representative of a community group (Table 1).

199 As the Terminal is a small port with limited economic and institutional reach, this sample of the
200 stakeholder cluster, taken in conjunction with the written reports, was considered adequate to
201 capture the experiences of the stakeholder cluster. Interviews were conducted in-person and by
202 telephone, using a semi-structured technique. In one case, two interviewees attended the same
203 interview; their responses were coded individually. The interview instrument (Appendix A) was
204 adapted from Becker et al. (2014) to elicit stakeholder impressions of what impacts from the
205 storm affected their institutions and to what parts of the stakeholder cluster the burden of
206 recovering from those impacts fell. The instrument was approved by the University of Rhode
207 Island Institutional Board. The interviews were recorded and transcribed for coding.

208 *Insert Table 1 about here*

209 Reports on Sandy's impacts from academic literature and from contemporaneous news
210 accounts were identified through internet searches and selected according to the criterion that
211 they catalog storm impacts on Red Hook Container Terminal or the broader PNYNJ system, as

212 reported by members of the port stakeholder cluster. Six scholarly articles and four
213 contemporaneous news reports were collected and coded (Table 2).

214 *Insert Table 2 about here*

215 Coding procedures from Becker et al. (2014) were employed in this study using the
216 NVivo qualitative data analysis software package to ensure that results were compatible.
217 Interview transcripts and reports were reviewed line-by-line and impacts were provisionally
218 identified. Once all potential impacts were highlighted, they were coded a second time to ensure
219 there was no duplication or conflation, and assigned to common ‘main ideas.’ Finally, ‘main
220 ideas’ were refined into explicit sub-types, and sub-type sets were coded into three top-level
221 types (direct, indirect, intangible impacts). The three top-level impact types used by the
222 International Panel on Climate Change were used for consistency and because they are
223 conceptually comprehensive – any articulable impact fits into at least one impact type (IPCC
224 2012). However, sub-types were coded independently without consulting the Becker et al. results
225 to avoid interpretive bias.

226 Impacts were articulated as specifically as possible to make the results comprehensive
227 and holistic; for instance, the impact of *disruption to the flow of food supplies* was kept distinct
228 both from the more general impact of *disruption of the flow of cargo*, and from the causally
229 related impact of *waterway closures*, according to how the respondent specifically expressed the
230 impact. Each impact mentioned in a written report was considered to have been mentioned only
231 once in that report regardless of how often the words appear in the text itself.

232 Once coded, impacts were then assigned to stakeholder groups according to the burden of
233 recovery. All impacts were parsed in this way, even where interviewees or reports were not

234 explicit about who ended up bearing the burden, based on the authors' best interpretation of the
235 contractual or jurisdictional obligations associated with each impact.

236 **4. Results**

237 Through analysis of five interviews and ten reports, 227 mentions of 82 distinct impacts
238 were identified, including 23 unique direct damage, 31 indirect costs and 28 intangible
239 consequences. The impacts are presented in Tables 3-5, divided into top-level impact types
240 (direct damage, indirect cost, or intangible consequence) and sub-types. For each impact, the
241 stakeholder group which carried the burden of recovering from the impact is identified.

242 **4.1 Direct Damages**

243 Direct damages, or damages with discrete costs incurred by the direct action of flooding
244 or wind on port facilities, equipment, and contents, are reported in Table 3. Damage to port
245 facilities was severe and widespread. Several structures on the Terminal experienced basement
246 and first floor flooding, and building contents across the Terminal including computer systems
247 and records were extensively damaged. Underground infrastructure such as electric substations,
248 storm drains, and fire pumps was destroyed.

249 *Insert Table 3 about here*

250 Port equipment was similarly hard hit, with cargo handling equipment disabled either by
251 water damage to engines or salt corrosion of wheels and electrical systems. Six electric gantry
252 cranes, which have their motors installed near ground level, were flooded out. Several of the
253 gantry cranes at RHCT had not yet been converted from diesel to electric to conform to
254 PANYNJ air quality guidance; these cranes were not disabled, while most of the rest of the
255 Port's crane equipment had to be dismantled and shipped out for refurbishment, which one
256 source reported cost about \$160,000 per crane. Some minor damage was done to barges at the

257 Terminal, although elsewhere in the Port one barge was stranded on a pier. Cargo was seriously
258 damaged, with numerous containers thrown around the Terminal and washed into the waterway.
259 One tenant reported that flooding of its warehouse resulted in \$10 million in write-offs.

260 **4.2 Indirect Costs**

261 Indirect costs, or disruptions to the normal flow of goods and services caused by direct
262 damages or by efforts to recover from them, are reported in Table 4. Key among these costs
263 incidental costs to repairing damages expressed in Table 3, such as assessment, monitoring,
264 security, and the provision of temporary replacement services.

265 *Insert Table 4 about here*

266 Apart from waterway closures and vessel evacuations, interruptions to operations also
267 stemmed from damage to administrative buildings, which destroyed paper records and disabled
268 computer systems. The interruption was felt by internal stakeholders, from the revenue gap for
269 tenants to lost wages for workers.

270 **4.3 Intangible Consequences**

271 Table 5 reports intangible consequences, encompassing a broad range of impacts that are
272 relevant to stakeholder decision-making, but nevertheless are poorly constrained by economic
273 valuation. This type includes a number of impacts which could feasibly be classified as direct
274 costs, such as damage to traffic signals, but which were cited by sources as conditions which
275 made recovery more difficult (i.e., the failure of traffic signals making travel to recovery sites
276 harder) rather than simply costs to be paid. In these cases, the impacts were recorded as reported
277 by the source.

278 *Insert Table 5 about here*

279 Sources strongly emphasized impacts, both on Terminal property and outside it, which
280 impaired their ability to bring the Terminal back online. Impacts on the Terminal included
281 damage to lighting and roads, debris on roads, and disruptions to communication systems. Not
282 only did the system back up seawater into facilities and make direct drainage impossible, but also
283 waste backed up through the storm drains because the City has a combined sewer system. This
284 meant that all water damage remediation activities required environmental hazard abatement
285 procedures as well.

286 Impacts outside the Terminal included severe cold weather during a fuel shortage, damage to
287 personnel's homes and communities preventing them from participating in recovery, and the
288 emotional toll of the widespread devastation. Finally, all interviewees discussed the complexity
289 of coordinating disaster relief efforts and funds within their institutional contexts.

290 **5. Discussion**

291 The experience of RHCT stakeholders in the aftermath of Hurricane Sandy demonstrated
292 the advantages and challenges of resilience planning to minimize the propagation of storm
293 impacts through the stakeholder cluster. Ports are highly interconnected and inter-reliant
294 systems. Stakeholders in the port stakeholder cluster rely on the goods and services of other
295 stakeholders through contractual, institutional, and cultural relationships. In a disaster, direct
296 damages to port facilities and resources propagate throughout the cluster along those reliant
297 relationships as indirect costs and intangible consequences.

298 Resilience planning ahead of the disaster event serves to anticipate the propagation of
299 impacts and develop working relationships between stakeholders that can be activated during the
300 response phase to abate impacts. Where impacts were not fully anticipated or working
301 relationships did not exist and had to be developed *ad hoc*, indirect and intangible impacts served

302 to impede response and prolong recovery. The specific experiences reported by Red Hook
303 stakeholders demonstrate the propagation of impacts through a port stakeholder cluster (section
304 5.1), and highlight both successes and failures of the port system’s response and recovery
305 attributable to pre-storm planning practices (section 5.2). Comparison to the reported outcomes
306 in a separate case (Gulfport, MS, USA after Hurricane Katrina) provide the basis for discussing
307 generalizable best practices for planning (section 5.3).

308 ***5.1 Direct damages propagate as indirect costs and intangible consequences***

309 Sources reported that before Sandy, hurricanes were considered, and planned for,
310 primarily as wind hazard events. Hurricane Sandy was primarily a storm surge event rather than
311 a wind event. All direct damages to port facilities highlighted in interviews and reports were the
312 results of flooding. One report cited this as the primary reason damage was so extensive: ‘The
313 storm surge was the big issue. With a hurricane you might expect a wind event with some
314 flooding. Instead we had a major flooding event with some wind damage’ (Wakeman & Miller
315 2013, 12).

316 *Insert Table 6 around here*

317 The building codes for PANYNJ facilities had emphasized protection from wind damage,
318 meaning that a great deal of critical port infrastructure – generators, transformers, motors, and
319 computer systems – was at or below ground level (DesRoches & Murrell 2014). Likewise, the
320 flat topography of the filled land in and around RHCT exposed the area to some of the most
321 severe flooding in the city.

322 The economic impact of the disruption to port commerce propagated to economic
323 dependents of the port in the hinterlands, ranging from clients of tug and barge, water taxi, and
324 ferry services, to the wider consumer goods marketplace. As one interviewee said: ‘there’s a lot

325 of things that sometimes people forget are on cargo containers, things like blood and food ...
326 things that are critical to emergency response. And it took a long time for that to get back up to a
327 moving pace.'

328 Economic hardship was a major point of discussion, especially regarding the disruption
329 of container traffic right at the opening of the holiday shopping season. Although interviewees
330 emphasized that critical port operations such as fuel deliveries came online quickly, container
331 operations took longer to reach pre-storm levels, both because they did not receive the same level
332 of public health emergency prioritization, and because the necessary equipment (e.g., gantry
333 cranes) took longer to repair.

334 The disruption of waiting on other members of the stakeholder cluster to resume
335 operations before being able to conduct one's own recovery efforts was also discussed as an
336 intangible but significant impact of the storm. One interviewee discussed how operators and
337 tenants could not resume full operations until PANYNJ could bring their own operations fully
338 online. Several sources discussed how all internal Terminal stakeholders relied on the USCG to
339 clear and reopen waterways before resuming port operations. An interviewee reported that
340 Customs and Border Patrol (CBP) lost critical hardware at the Manhattan Cruise Terminal for
341 identifying and processing arriving passengers (e.g., scanning passports), which forced them to
342 turn away a cruise ship which had weathered the storm at sea and subsequently had to be
343 rerouted to Boston. All sources emphasized the reliance of the surrounding community on the
344 port for fuel and for commerce.

345 ***5.2 Resilience planning builds relational capacity to stem the propagation of impacts***

346 Resilience planning can provide a mechanism for stakeholders in the port stakeholder
347 cluster to establish working relationships that can be activated to coordinate response and

348 recovery. The experience of recovering the channel versus recovering the fuel system highlight
349 the effect of resilience planning in building such institutional relationships. Port hazard planning
350 with internal stakeholders, tenants and clients, and public policy stakeholders including the City
351 and the USCG prepared the port system to abate navigational hazards and reopen the waterways
352 efficiently, minimizing indirect costs and intangible impacts. By contrast, an enduring fuel
353 shortage, which was prolonged and exacerbated by an inability to coordinate response
354 operations, caused a significant portion of indirect costs and intangible consequences suffered by
355 stakeholders across the cluster.

356 5.2.1 Waterway response and recovery

357 The waterways remained closed until impairments to navigation could be abated.
358 Waterway closures were the initial cause of the port shutdown, as the USCG evacuated the
359 harbor before the storm. Immediately after, USCG activated a pre-existing response network of
360 government and non-government vessels to survey the waterways for navigational safety,
361 including identifying debris and shoaling, and assessing the status of aids to navigation - an
362 effort which was impaired by damage to their own equipment and facilities. This process
363 involved repairing aids to navigation and clearing obstacles such as drifting vessels, containers,
364 oil spills, and other various hazards. Floating containers were highlighted by multiple sources as
365 a significant challenge, as they can severely damage a vessel in a collision, but can often float
366 slightly below the water's surface, making them difficult to avoid.

367 The burden of abating the container problem complicated response efforts. Although the
368 USCG had jurisdictional responsibility to survey and identify containers that had floated off the
369 terminals in the surge, the practical responsibility of who would pay to remove any given
370 container was not always clear. For containers that were sufficiently intact to identify the owner

371 by serial number, the owner had clear liability to cover the cost of removal. If the container was
372 damaged such that the owner could not be ascertained, and it posed a risk of polluting the
373 waterway, the Coast Guard had access to dedicated funds to cover removal. If the container was
374 damaged and was found in the waterway, the USACE took responsibility for removing it as an
375 obstacle to navigation. However, a great number of containers beached alongside the waterway
376 did not fall into those categories – the Coast Guard surveyed and catalogued these containers but
377 did not have clear guidance on how to obtain funds for their removal. An interviewee reported
378 that in many cases, these containers ended up being removed at the expense of the landowner or
379 the city.

380 Despite uncertainty regarding debris outside the channel, interviewees described that
381 USCG was able to successfully collaborate within the port stakeholder cluster, including
382 PANYNJ, tenants, and pilots, to accelerate waterway inspection and cleanup. USCG prioritized
383 reopening the waterways to key fuel terminal facilities. Priority routes to fuel terminals were
384 restored within days, making possible emergency fuel delivery operations to affected parts of the
385 City. RHCT, as a container terminal, received lower priority but was navigable within eight days.
386 Sources stated that this coordination was possible due to preexisting institutional relationships
387 developed through the disaster recovery planning process.

388 5.2.2 Power system response and recovery

389 The response network developed through prior port resilience planning had not, however,
390 developed similar lines of communication with regional electric utilities. Extensive damage to
391 subterranean infrastructure across the city left the electric grid disabled for days, cutting off
392 internet access and requiring stakeholders to obtain back-up generators. The huge demand for

393 fuel for generators, combined with the power outage itself disabling otherwise operational fuel
394 terminals, in turn created a severe fuel shortage.

395 As discussed above, USCG prioritized reopening deliveries to certain fuel terminals that
396 had received less damage. This allowed the government to begin to make emergency fuel
397 deliveries to shelters and hospitals. However, many fuel terminals were unable to resume
398 operations due to damaged tanks, flooded pumps, and the ongoing electrical outage.

399 Because the port community was effectively left to sit on its hands waiting for electrical
400 systems to recover, it was not able to stem the fuel shortage even once waterways and terminal
401 facilities were otherwise ready to reactivate. With response and recovery delayed relative to the
402 waterway navigability, sources across the stakeholder cluster reported indirect and intangible
403 effects of the power shortage at a higher rate than those consequent to other direct impacts. As
404 one interviewee reported, '[the surrounding communities] had no gas. Many needed gas to fill
405 generators, to get power back up at their house and keep the heat on ... As soon as power went
406 out, a lot of people went to generator systems and the generators started to go out. Then at the
407 same time, the temperature dropped pretty precipitously. And so you had this confluence of
408 people needed fuel for heat, fuel for electricity, fuel for their cars, fuel for all sorts of things, and
409 it wasn't readily available.'

410 Electricity, therefore, represented a bottleneck in the critical path to recovery, which an
411 interviewee indicated was a consequence of the inability of stakeholders to coordinate ahead
412 with the utilities through the resilience planning process. The knock-on, externalized burden of
413 recovering under these circumstances fell to port tenants and operators (e.g., by using backup
414 generators during the repair process) and to the public policy and community groups which

415 offered emergency services to those without power (e.g., government fuel deliveries by truck,
416 and community aid groups providing warm shelters).

417 5.2.3 Adaptivity in response and recovery

418 Across stakeholder groups, new systems and procedures for communicating, problem
419 solving, and processing paperwork had to be innovated on the fly. One interviewee expressed
420 that the mix of impaired roads, fuel shortages, and damage to personnel's homes severely short-
421 staffed PANYNJ in the first days after the storm, necessitating that the personnel on hand step
422 into inspection and decision-making roles that were outside their normal work responsibilities.
423 For instance, one interviewee reported that road and rail inspections had to be performed by
424 whoever could report to work on the day after the storm, because most of the regular inspectors
425 lived in New Jersey and couldn't get into the city by car. This delayed the recuperation of the
426 land transport network and cut off repair personnel and equipment.

427 Because of this complexity, interviewees strongly emphasized the importance of
428 adaptivity and coordination among stakeholders during the recovery process. Several
429 interviewees described coordinating major governmental response efforts using a daisy chain of
430 officials' personal cell phones, depending on which carrier was online that day.

431 Strong institutional relationships also empowered stakeholders to respond adaptively. For
432 instance, perimeter fences and cameras were destroyed throughout the Port; this brought the
433 Terminal and other Port facilities out of compliance with the Maritime Transportation Security
434 Act (MTSA), which requires terminal operator to continuously maintain security equipment and
435 procedures (MTSA 2002). An interviewee reported that the USCG, which enforces the MTSA,
436 worked with terminal operators across the Port in the hours after the storm to identify breaches
437 and execute temporary plan amendments under USCG regulations to fill the breaches using hired

438 security monitoring. As the interviewee put it, ‘the minute the Facility Security Officer could get
439 out to the facility and assess what was going on, most of them were on the horn with their
440 corporate headquarters and within 12 hours you had privately hired sheriffs from Louisiana
441 doing gate-guard duty.’ No indirect costs or intangible consequences related to security issues
442 (e.g. looting) were reported by any sources.

443 ***5.3 Contrasting findings from Gulfport, MS***

444 . The Port of Gulfport, MS is Mississippi’s largest port, and it experienced profound
445 damage from Hurricane Katrina in 2005. Becker et al. (2014) reported impacts from Katrina on
446 the port and surrounding community using the same methodology.

447 Nearly all Red Hook interviewees emphasized the rapid turnaround of port recovery.
448 While community stakeholders in Red Hook have indicated that economic recovery in the
449 community has been protracted and remains incomplete, the port system resumed critical
450 operations within 10 days. This stands in sharp contrast with the severe, long-term shutdown at
451 Gulfport and the associated intangible consequences identified, such as supply-side fluctuations
452 in the labor market, complete facility destruction and reconstruction, and permanent loss of
453 revenue or lines of business.

454 This distinction points to a disparity in the economic and institutional capacity of the two ports’
455 different stakeholder clusters to recover, as well as the effectiveness of recovery activities
456 coordination across those clusters. Becker et al. found that existing resilience planning processes
457 in Gulfport revolved around the responsibilities and interests of internal and economic external
458 stakeholders, without involving other external stakeholders, and that, as a consequence, planning
459 processes failed to account for significant portions of the impacts experienced after Hurricane
460 Katrina, especially indirect and intangible impacts which impaired long-term recovery. The

461 experience of RHCT drives this point home by illustrating that, where resilience planning
462 anticipated impacts and built institutional relationships that could be activated to coordinate
463 response and recovery, response operations brought systems online quickly, such as in the case
464 of waterway debris clearing, whereas unanticipated impacts led to lack of coordination and
465 enduring impairment of recovery, such as in the case of the fuel shortage.

466 **6. Conclusion**

467 This case study of the Red Hook Container Terminal in Hurricane Sandy extends the
468 methods of Becker et al. (2014) to the highly integrated, intermodal port system of New York
469 City. Interviews with key stakeholders indicated clear interdependencies among stakeholders in
470 ability to storm recovery activities, caused by indirect and intangible impacts which propagated
471 across the stakeholder cluster. Where the disaster planning process had instituted post-disaster
472 coordination frameworks for those interdependencies – such as in the case of regional fuel
473 supplies – stakeholders were able to coordinate and rapidly recover. Where institutional lines of
474 coordination did not exist – such as in the case of the electrical grid – the recovery process was
475 impaired and secondary costs were incurred to endure the impact during the recovery process.
476 The results from Red Hook emphasize that coordination between stakeholder institutions is an
477 effective strategy for efficiently recovering from major storm events. Information like the
478 stakeholder impacts solicited in this project can inform and support the capacity of resilience
479 planning to comprehensively involve all relevant stakeholders in a port system in procedures and
480 investments to build port resilience.

References

- Aerts, J., Botzen, W., Clarke, K., Cutter, S., Hall, J., Merz, B., Michel-Kerjan, E., Mysiak, J., Surminski, S., Junreuther, H. 2018. Integrating human behaviour dynamics into flood disaster risk assessment. *Nature Climate Change* 8:193–199.
- Becker, A., Acciaro, M., Asariotis, R., Carera, E., Cretegny, L., Crist, P., et al. 2013. A Note on Climate change adaptation for seaports: A challenge for global ports, a challenge for global society. *Climatic Change* 120 (4):683-95.
- Becker, A., Matson, P., Fischer, M., and Mastrandrea, M.D. 2014. Towards seaport resilience for climate change adaptation: Stakeholder perceptions of hurricane impacts in Gulfport (MS) and Providence (RI). *Progress in Planning* 99:1-49.
- Becker, A., Ng, A., McEvoy, D., Mullett, J. 2018. Implications of climate change for shipping: Ports and supply chains. *Wiley Interdisciplinary Reviews: Climate Change* 9 (2):e508.
- Blake, E.S. 2013. *Tropical Cyclone Report: Hurricane Sandy*. National Hurricane Center, AL182012.
- Bryson, J.M. 2004. What to do when stakeholders matter: Stakeholder identification and analysis techniques. *Public Management Review* 6 (1):21-53.
- Campbell, R. 2012. “Sandy snarls NY Harbor oil logistics, NYMEX gasoline delivery.” *Reuters*, 1 Nov.
- CMTS (Committee on the Maritime Transportation System). 2017. *National Strategy for the Marine Transportation System: Channeling the Maritime Advantage 2017-2022*.
- Curtis, S.A. 2007. *Hurricane Katrina Damage Assessment: Louisiana, Alabama, and Mississippi Ports and Coasts*. American Society of Civil Engineers, Reston, Virginia.
- De Langan, P.W. 2004. *The Performance of Seaport Clusters*. Erasmus University Rotterdam.
- DesRoches, S. and Murrell, S. 2014. Transportation Infrastructure Resiliency Guidelines for the Port Authority of New York & New Jersey. *Proceedings of the Transportation & Development Institute Congress 2014*. American Society of Civil Engineers.
- Di Baldassarre, G., Viglione, A., Carr, G., Kuil, L., Yan, K., Brandimarte, L., Blöschl, G. 2015. Debates—Perspectives on socio-hydrology: Capturing feedbacks between physical and social processes. *Water Resources Research* 51:4770– 4781.
- EPA (United States Environmental Protection Agency). 2008. *Planning for Climate Change Impacts at U.S. Ports*. White Paper prepared by ICF International for the USEPA.

- Flyvbjerg, B. 2006. Five misunderstandings about case-study research. *Qualitative inquiry* 12, 219-245.
- Freeman, R.E. 2010. *Strategic management: A stakeholder approach.*, Cambridge: Cambridge University Press.
- Gebrekidan, S. 2012. “More NY oil terminals online, gasoline lines persist post Sandy.” *Reuters*, 4 Nov.
- Grossi, P., Kunreuther, H., and Windeler, D. 2005. An introduction to catastrophe models and insurance. *Catastrophe Modeling: A New Approach to Managing Risk*. 23-42
- Hallegatte, S., Ranger, N., Mestre, O., Dumas, P., Corfee-Morlot, J., Herweijer, C., and Wood, R.M. 2011. Assessing climate change impacts, sea level rise and storm surge risk in port cities: a case study on Copenhagen. *Climatic Change* 104 (1):113-137.
- IPCC (International Panel on Climate Change). 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Cambridge, UK: Cambridge University Press.
- Jaffe, D. C. 2015. Excess All-Cause Mortality after Hurricane Sandy, NYC 2012-2013. In *Proceedings of the 2015 CSTE Annual Conference*.
- LADOT (Louisiana Dept. of Transportation & Dev. Office of Public Works and Intermodal Transportation). 2006. *Status Report of Louisiana Ports from Hurricane Katrina*.
- Lian, C., Santos, J.R., and Haimes, Y.Y. 2007. Extreme risk analysis of interdependent economic and infrastructure sectors. *Risk Analysis*. 27 (4):1053-1064.
- Maritime Transportation Security Act of 2002, 46 U.S.C. § 70101 *et seq.* (2002).
- MarEx Staff. 2012. “Update: Assessment and Response from Storm Damage Caused by Hurricane Sandy Begins.” *Maritime Executive*, 2 Nov.
- Melillo, J.M., Richmond, T., and Yohe, G.W. (Eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*, Washington, DC: U.S. Global Change Research Program.
- Messner, S., Becker, A., and Ng, A.K.Y. 2015. Seaport adaptation for climate change - The roles of stakeholders and the planning process. In *Climate Change and Adaptation Planning for Ports*. Abingdon-on-Thames: Routledge.
- Moser, S. and Ekstrom, J. 2010. A framework to diagnose barriers to climate change adaptation. *Proceedings of the National Academy of Sciences* 107 (51):22026.

- NAIC (National Infrastructure Advisory Council). 2015. *Transportation Sector Resilience Final Report and Recommendations*.
- Ng, A., Becker, A., Cahoon, S., Chen, S.-L., Earl, P., and Yang, Z. *Climate Change and Adaptation Planning for Ports*. NY, NY: Routledge; 2016.
- NYS2100. 2013. *Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure*. Albany: NYS2100 Commission.
- PortSide NewYork. 2016. *Red Hook WaterStories: Red Hook Container Terminal*. New York: PortSide NewYork. < <https://redhookwaterstories.org/exhibits/show/rhct/rhct>>.
- "Brooklyn Specs." *Red Hook Terminals*. Red Hook Terminals LLC, Web. Accessed 15 Feb. 2019. <<http://www.redhookterminal.com/>>.
- Smythe, T. 2013. *Assessing the Impacts of Hurricane Sandy on the Port of New York and New Jersey's Maritime Responders and Response Infrastructure*. Center for Maritime Policy & Strategy, U.S. Coast Guard Academy.
- Stempel, P., Ginis, I., Ullman, D., Becker, A., Witkop, R. Real-Time Chronological Hazard Impact Modeling. *Marine Science and Engineering* 6 (4):134 (2018).
- Strunsky, S. 2012. "Port Resumes Operation in Sandy's Wake." *NJ.com*. 4 Nov.
- UNCTAD (United Nations Conference on Trade and Development). 2018. *Review of Marine Transport 2018*. UNCTAD/RMT/2018.
- USDOT (United States Department of Transportation). 2014. *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure The Gulf Coast Study, Phase 2 Screening for Vulnerability Final Report, Task 3.1*. Washington, DC. Report No.: FHWA-HEP-14-033 U.S.
- Wakeman, T.H., and Miller J. 2013. *Lessons from Hurricane Sandy for Port Resilience*. New York: University Transportation Research Center - Region 2.
- Ward, D. 2001. Stakeholder involvement in transport planning: Participation and power. *Impact Assessment and Project Appraisal*. 19 (2):119–130.
- Yin, R. 2008. *Case study research: Design and methods*. Newbury Park: Sage Publications,
- Zhang, H., Ng, A., Becker, A. 2017. "A Critical Discussion on the Roles of Institutions on Ports' Adaptation to the Impacts Posed by Climate Change." In *Climate Change Adaptation in North America*, edited by Walter Filho and Jesse Keenan, 105-117. Cham: Springer.

Appendix A – Interview Instrument
INTERVIEW INSTRUMENT FOR RED HOOK, NEW YORK
Modified from Becker 2014

INFO = Information to be given to informant
Blue = notes for interviewer

OVERVIEW

Respondent Name; Date; Interviewer; Organization; Position.

Section I: Background on institutions and interviewees (5 minutes)

INFO: There are 13 questions, concerned with your organization's relationship to Red Hook Terminal and to your organization's experiences in the aftermath of Sandy. I will record the interview. Your responses to these questions will be kept private, and neither your name nor your organization's name will be tied to any specific response, either in internal transcripts or in any publications. This should take about 30 minutes.

Please tell me about your organization's management responsibilities.

(Setting the stage here to have the scope of jurisdiction and mandate in their words, and get at interactions among stakeholders)

Follow up (FUP) A: Could you tell me a bit about the *current priorities* your organization has?

FUP B: Does your organization interact with other local, state, regional or even federal agencies or companies to do its work?

And what specifically does your work entail?

FUP A: So you manage What does that actually mean as far as your daily work is concerned?

FUP B: Who do you interact with regularly to accomplish this?

FUP C: How long have you been in this position?

FUP D: What is your education background (degrees and discipline)?

Can you describe the *decision-making process* for long-term planning and investing bit more?

These questions are likely to bring out issues of conflict, institutional cooperation or lack thereof. They are included for completeness.

FUP A: Who applies/proposes/initiates?....

FUP B: Who else is involved?

FUP C: Are your decisions reviewed by some higher authority?

FUP D: Can anyone appeal or supersede your decisions? How does that process work?

FUP E: What information is required so you can make an adequate assessment?

FUP F: How long does it take to complete one project/application? How often do you have to make these kinds of decisions?

FUP E: What are the most significant changes in your work in the last five years (assuming the person has been in this or similar position for this long)

This research is about the "port system." This includes all of the various functions, costs, and benefits of the port that could be of concern for the region. Please tell us about your organization's management or planning responsibilities in terms of the port system.

FUP A: Could you tell me a bit about the *current priorities* your organization has with respect to the port?

FUP B: Does your organization interact with other local, state, regional or even federal agencies or companies to do its work and meet its port-related goals?

FUP C: How does the port fit under your organization's mandate?

FUP C: How does the port fit under your organizations jurisdiction?

FUP D: To what extent is your organization dependent on the success of the port?

Section II. Impacts of storm events (20 minutes)

INFO: Present the interviewee with the storm scenario and functions of the port.

Let's turn to your experience with Sandy. The port has a number of functions for the region and these functions were impacted by the storm. As we go through the rest of the interview, I'd like you to consider this storm event and the functions of the port as you answer the questions.

Did you have to prepare/account/plan for these kinds of events?

FUP A: In what ways, how so, etc.

Consider how Sandy impacted Red Hook Terminal and the surrounding neighborhood. How did the storm affect the resources and responsibilities within your jurisdiction (including infrastructure, social well-being, ecosystems, etc.)?

FUP A: What were your immediate concerns?

FUP B: What impacts were difficult to address in the immediate aftermath?

FUP C: Can you get more specific on what the impacts were?

Probe for STEEPLE impacts – six drivers of decision making (drivers of change)

S – Social T – Technological EN – Environmental EC – Economic P – Political LE – Legal

<i>Environmental</i>	<i>Social</i>	<i>Economic</i>	<i>Infrastructure</i>	<i>Other</i>
Petroleum Release	Jobs lost/unemployment	Lost business	Power outage	Loss of competitive advantage
Hazmats released	Jobs created	Tenants relocate	Water supply	Fences and signs
Debris (small)	Workers displaced	Cleanup costs	Utilities (general)	Tree debris
Debris (large)		Preparation costs	Cranes damaged	Lost data
		Repair costs	Roads/Bridges	
		Damage to product	Rail	
		Can't get insurance	Piers	
			On-site buildings	

FOR EACH IMPACT:

You described one impact ... How was your organization affected by that impact?

INFO: Interested not only in damage and costs but also effects on ability to operate.

FUP A: How did operations have to change to accommodate the impact?

FUP B: How long did the impact affect operations?

FUP C: Were there permanent consequences of that impact on the organization?

Who else was affected in that way by that impact?

How did your organization deal with that impact?

FUP A: What resources were available to you to respond? Were they sufficient?

FUP B: What plans or policies did you have in place? Were they effective?

FUP C: What information was available to you to enable decision-making? Was it sufficient?

Who was responsible for dealing with or resolving the consequences of that impact?

INFO: I am interested not just in who paid and how they paid for it, but also who had to dedicate time and labor, handle paperwork and liaise with other organizations.

FUP A: Was the impact anticipated or was there a gap in responsibilities or organizations' understanding of each other's responsibilities?

Who actually ended up dealing with or resolving the consequences of that impact?

FUP A: Did someone have to step in to handle the impact?

FUP B: Was there a gap in responsibilities or organizations' understanding of each other's responsibilities?

Has your organization changed any policies or taken any steps to prepare for the next storm, in response to your experiences dealing with that impact?

Closing. [at discretion, depending on length of interview]

Is there anything else we might have missed that you want to add about the storm resilience process you've gone through so far?

Are there any other stakeholders for Red Hook Terminal that I should be speaking with for this project? Who in that organization should I speak to about these issues?

TABLES AND FIGURES

Table 1 – Interviewees

Stakeholder	Organization	Port Interest	Interviews
Internal	Port Authority of New York & New Jersey	Lessor of Terminal land and facilities	2
External: Public Policy	US Coast Guard	Inspect and maintain waterways and port security	2
External: Community	PortSide New York	Preserve and advocate for maritime culture in Red Hook	1

Table 2 – Written Sources

Source	Title	Type	Objectives
Smythe 2013	Assessing the Impacts of Hurricane Sandy on the Port of New York and New Jersey’s Maritime Responders and Response Infrastructure	Academic	Identify lessons learned from maritime responders, including first responders, to Sandy.
Wakeman & Miller 2013	Lessons from Hurricane Sandy for Port Resilience	Academic	Interview stakeholders and review design codes to identify opportunities to enhance resilience.
DesRoches & Murrell 2014	Transportation Infrastructure Resiliency Guidelines for the Port Authority of New York & New Jersey	Academic	Describe changes to PANYNJ Design Guidelines made in post-Sandy review.
PortSide New York 2016	Red Hook WaterStories: Red Hook Container Terminal	Virtual Museum	Record culture and history of the Red Hook community through oral histories and feature essays.
NYS2100 2013	Recommendations to Improve the Strength and Resilience of the Empire State’s Infrastructure	Gov’t Report	Identify vulnerabilities and recommend resilience improvements for all state infrastructure.
NIAC 2015	Transportation Sector Resilience Final Report and Recommendations	Gov’t Report	Identify gaps and opportunities in national transportation system resilience.
MarEx Staff 2012	Update: Assessment and Response from Storm Damage Caused by Hurricane Sandy Begins	Journalism	October 30, 2012
Campbell 2012	Sandy snarls NY Harbor oil logistics, NYMEX gasoline delivery	Journalism	November 1, 2012
Gebrekidan 2012	More NY oil terminals online, gasoline lines persist post Sandy	Journalism	November 4, 2012
Strunsky 2012	Port resumes operations in Sandy’s wake	Journalism	November 4, 2012

Table 3 – Direct Damages

Table 3 - Direct Damages	Port Authority (Internal)	Operator (Internal)	Tenants & Clients (Contractual)	Public Policy	Community
Table of direct damages reported by interviewees and reports. X's in rightmost columns indicate stakeholder groups which bore the burden of recovering from each impact by, for instance, paying the costs of repairs.					
Damage to port facilities					
Damage to berths		X	X	X	
Damage to security cameras		X	X	X	
Damage to security fence		X	X	X	
Damage to water pump at fire stations	X			X	
Damage to fuel pumps		X	X	X	
Damage to oil tanks		X	X	X	
Damage to pump stations	X			X	
Damage to sheds		X	X	X	
Damage to storm drains	X			X	
Damage to transformers		X	X	X	
Damage to underground infrastructure (generally)	X	X	X	X	
Damage to port facilities (generally)	X	X	X	X	
Damage to terminal equipment					
Damage to cargo handling equipment		X		X	
Damage to computer systems	X	X	X	X	
Damage to cranes		X		X	
Damage to CBP radiological screening equipment				X	
Damage to trucks		X	X	X	
Damage to vessels					
Barge stranded on berth			X		
Damage to barges (generally)			X		
Damage to goods or cargo					
Flooded cars			X		
Containers washed away			X		
Damage to goods or cargo (generally)			X		

Table 4 – Indirect Costs

Table 4 - Indirect Costs	Port Authority (Internal)	Operator (Internal)	Tenants & Clients	Public Policy	Community
Table of indirect reported by interviewees and reports. X's in rightmost columns indicate stakeholder groups which bore the burden of recovering from each impact by, for instance, writing off lost revenue.					
Costs of Recovery					
Cost of renting generators to run cranes during repairs		X			
Cost of environmental compliance during repairs	X	X	X	X	
Cost of hiring private security during repairs to security systems		X			
Obligation to conduct facility inspections to identify damages	X	X	X		
Costs of retrieving rerouted cargo			X		
Obligation to survey aids to navigation				X	
Obligation to conduct facility security inspections	X	X	X	X	
Obligation to survey waterways for shoaling				X	
Obligation to survey waterways for debris/obstacles				X	
Cost of oil spill containment		X	X		
Costs of environmental hazard containment (generally)	X	X	X	X	
Navigational Impairment					
Damage to aids to navigation				X	
Adrift vessels			X	X	X
Containers floating in the waterway			X	X	
Debris in waterway			X	X	
Interruptions to Operations					
Closure of waterways				X	
Damage to administrative offices impaired operations	X	X	X	X	
Evacuation of vessels from the harbor			X		
Lost wages					X
Interruption to operations during recovery (generally)	X	X	X	X	X
Impacts on Port-Dependent Commerce					
Disruption of sewage transit services				X	
Disruption of tug and barge service			X		
Disruption of water taxi service			X		
Disruption of ferry service			X		
Cargo delayed and rerouted to other ports			X		
Disruption of the flow of blood and medical supplies			X	X	X
Disruption of the flow of emergency supplies			X	X	X
Disruption of the flow of food supplies			X	X	X
Disruption of the flow of goods (generally)			X	X	X
Widespread, long-term fuel shortage		X	X	X	

Table 5 – Intangible Consequences

Table 5 - Intangible Consequences	Port Authority (Internal)	Operator (Internal)	Tenants & Clients	Public Policy	Community
Table of intangible consequences reported by interviewees and reports. X's in rightmost columns indicate stakeholder groups which bore the burden of recovering from each impact by, for instance, dedicating time and effort to resolving an impairment of normal operations.					
Port Damages which Impair Port Recovery					
Private operations cannot resume until PANYNJ operations resume	X				
Disruption to communication systems				X	X
Inability to use roads due to damaged traffic signals	X	X		X	
Inability to work effectively due to damaged lighting	X	X	X	X	
Debris on roads and terminals	X	X	X	X	
Damage to equipment for harbor surveying				X	
Sewage backup from overflowing combined sewers	X	X		X	
Damage to back-up generators	X	X		X	
Emergency Conditions which Impair Port Recovery					
Severe cold without fuel supplies	X	X	X	X	X
Obligation to revisit and reassess pre-storm long-term plans	X	X	X	X	
Burdensome paperwork	X	X	X	X	X
Widespread, long-term power outages	X	X	X	X	X
Stress from performance of tasks outside training and job duties	X	X	X	X	
Difficulty learning new disaster recovery regulations and procedures	X	X	X	X	
Personnel unable to reach port facilities	X	X	X	X	
Personnel contending with damage to own homes	X	X	X	X	X
Emotional toll of the widespread damage	X	X	X	X	X
Widespread devastation throughout the community (generally)				X	X
Port-Related Damages to the Surrounding Community					
Ecological damage of oil spills		X		X	
Oil carried inland by surge					X
Sediment washed onto shore				X	X
Containers washed onto shore			X	X	X
Consequences of Port Disruption to the Broader Economy					
CBP operations delayed by damage to computer systems				X	
Cruise ships rerouted from destination			X		
Cruise ships' passengers' cars destroyed in terminal parking lots					X
Disruption of the flow of goods during the holiday season			X		X
Disruption of the global supply chain		X	X		
Disruption of international fuel market due to fuel shortage		X	X		
Impairment of regional recovery due to fuel shortage				X	X

Table 6 – Impacts Reported as Affecting 4 or 5 Categories of Stakeholder

Table 6 – Impacts Reported as Affecting 4 or 5 Categories of Stakeholder	Port Authority (Internal)	Operator (Internal)	Tenants & Clients (Contractual)	Public Policy	Community
X's in rightmost columns indicate stakeholder groups which bore the burden of recovering from each impact.					
Direct Damages – Damage to port facilities					
Damage to underground infrastructure (generally)	X	X	X	X	
Damage to port facilities (generally)	X	X	X	X	
Direct Damages – Damage to terminal equipment					
Damage to computer systems	X	X	X	X	
Indirect Costs – Costs of Recovery					
Cost of environmental compliance during repairs	X	X	X	X	
Obligation to conduct facility security inspections	X	X	X	X	
Costs of environmental hazard containment (generally)	X	X	X	X	
Damage to administrative offices impaired operations	X	X	X	X	
Interruption to operations during recovery (generally)	X	X	X	X	X
Intangible Consequences – Port Damages which Impair Port Recovery					
Damage to lighting	X	X	X	X	
Debris on roads and terminals	X	X	X	X	
Intangible Consequences – Emergency Conditions which Impair Port Recovery					
Severe cold weather following days after the storm cut off fuel supplies	X	X	X	X	X
Obligation to revisit and reassess pre-storm long-term plans	X	X	X	X	
Burdensome paperwork	X	X	X	X	X
Widespread, long-term power outages	X	X	X	X	X
Personnel must perform tasks outside their training and job duties	X	X	X	X	
Difficulty learning new disaster recovery regulations and procedures	X	X	X	X	
Personnel unable to reach port facilities	X	X	X	X	
Personnel contending with damage to own homes	X	X	X	X	X
Emotional toll of the widespread damage	X	X	X	X	X

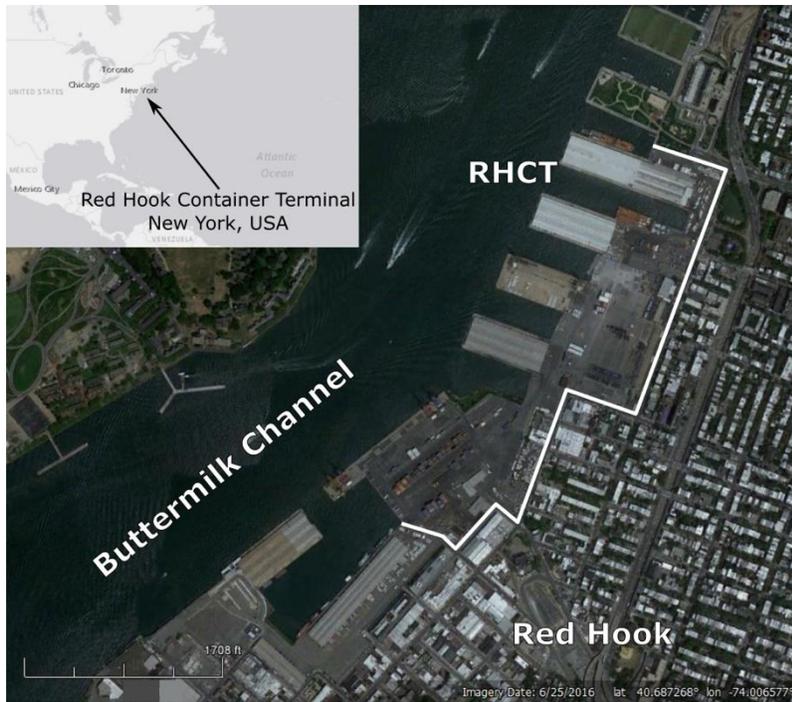


Figure 1:
Red Hook Container Terminal is in Brooklyn, New York, USA at the mouth of New York Harbor and is the easternmost terminal in the Port of New York and New Jersey. The terminal is positioned along Buttermilk Channel, across from Governor's Island. Imagery generated by Google.