Productivity Commission Inquiry 2019
Resources Sector Regulation

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(1) This submission is based upon my experience as an ecologist, engineer and regulator over a forty year working history in various different resources areas including forestry, heavy industry, chemical manufacturing, mining, the defence sector and petroleum. As an environmental regulator I worked at state level in Queensland focusing on technical regulation of the unconventional resource sector and also worked with the UK Environment Agency (environmental risk management) in Cornwall, UK and the US Environment Protection Agency (coal seam gas and shale gas waste water management), Washington, DC.

(2) I have recently completed a PhD (The University of Queensland) examining the structure and function of regulation from jurisdictions across the world constraining hydraulic fracturing (fracking) in the unconventional resources area (eg. shale oil and gas, and coal seam gas). This research has direct relevance to the subject matter of this inquiry and my evidence may help the Commission in its determinations and development of recommendations to the Treasurer. This submission fulfils the essential elements of an evidence-based statement as opposed to a policy wish list.

(3) **Scope.** The scope of the inquiry is wide but reasonable, with sufficient related matters to hold relevance. The US is a fountain of knowledge in this area at government level and within law schools. Of particular value is the Federal Congressional Research Service where many studies are pursued depending upon interests of Congress (https://crsreports.congress.gov/) and also the US Government Accountability Office (https://www.gao.gov/). Of specific relevance to the petroleum sector, the oil and gas producing state regulators in the US have co-operated in the assessment of individual state petroleum regulations to achieve a level of regulatory conformance. This organization, STRONGER (State Review of Oil and Gas Regulations- https://www.strongerinc.org/), has also developed multilingual manuals of practice to assist field crew in the pursuit of safe working practices.

(4) **Assessment criteria for best practice regulation.** An important aspect missing from **Regulatory design** is the fundamental need for: *regulation to address market failure.* Market failure could be seen as addressing both internal bias and failure to address harms through not managing externalities by responsible parties.

(5) **Regulatory design.** The following paragraphs draw significantly from my research and thesis (Campin 2018) which examined the structure and function of regulations constraining hydraulic fracturing in unconventional resource reservoirs from jurisdictions across the world. For this research some 2,000 regulatory statements (a single purpose legal statement) were extracted from petroleum development legislation enacted in Colorado, Illinois, Pennsylvania, Wyoming, Alberta, British Columbia, New South Wales, Queensland, South Australia, Western Australia, South Africa and Brazil. Due to different regulatory styles applied by these jurisdictions a grammatical analysis methodology, the *institutional grammar tool*, was used to extract key elements of each statement and allow them to be compared directly. The methodology is provided as a forerunner to some of the major findings that show some salient relationships between regulatory form (ie. the spectrum of regulatory form, prescription through to performance based regulation) and development outcomes.

(6) **Key findings. Table 1** was developed based upon the findings identifying regulatory form used to constrain aspects of hydraulic fracturing within the different jurisdictions, however, its application has been found to be quite universal across many areas of regulation, not restricted to resource management. **Figure 1** shows the application of this typology to resource development data.

Table 1: Regulatory statement form typology

<table>
<tr><th colspan="2">Prescription element</th><th></th><th colspan="2">Performance element</th></tr>
<tr><th>Internal-focus</th><th>Output-focus</th><th colspan="2">Process element</th><th rowspan="2">Performance: quantitative</th></tr>
<tr><td>Prescription: power</td><td rowspan="2">Prescription: action</td><td rowspan="2">Process: party plan</td><td>Principle:party plan-quantitative</td></tr>
<tr><td>Prescription: mandate</td><td>Principle:party plan-qualitative</td><td rowspan="2">Performance: qualitative</td></tr>
<tr><td>Prescription: responsibility</td><td rowspan="2">Prescription: specification</td><td rowspan="3">Process: authority</td><td rowspan="2">Principle: authority-qualitative</td></tr>
<tr><td>Prescription: liability or defence</td></tr>
<tr><td>Prescription: prohibition</td><td rowspan="2">Prescription: evidence, discovery or notification</td><td rowspan="2">Principle: authority-quantitative</td><td rowspan="2"></td></tr>
<tr><td>Prescription: exemption</td></tr>
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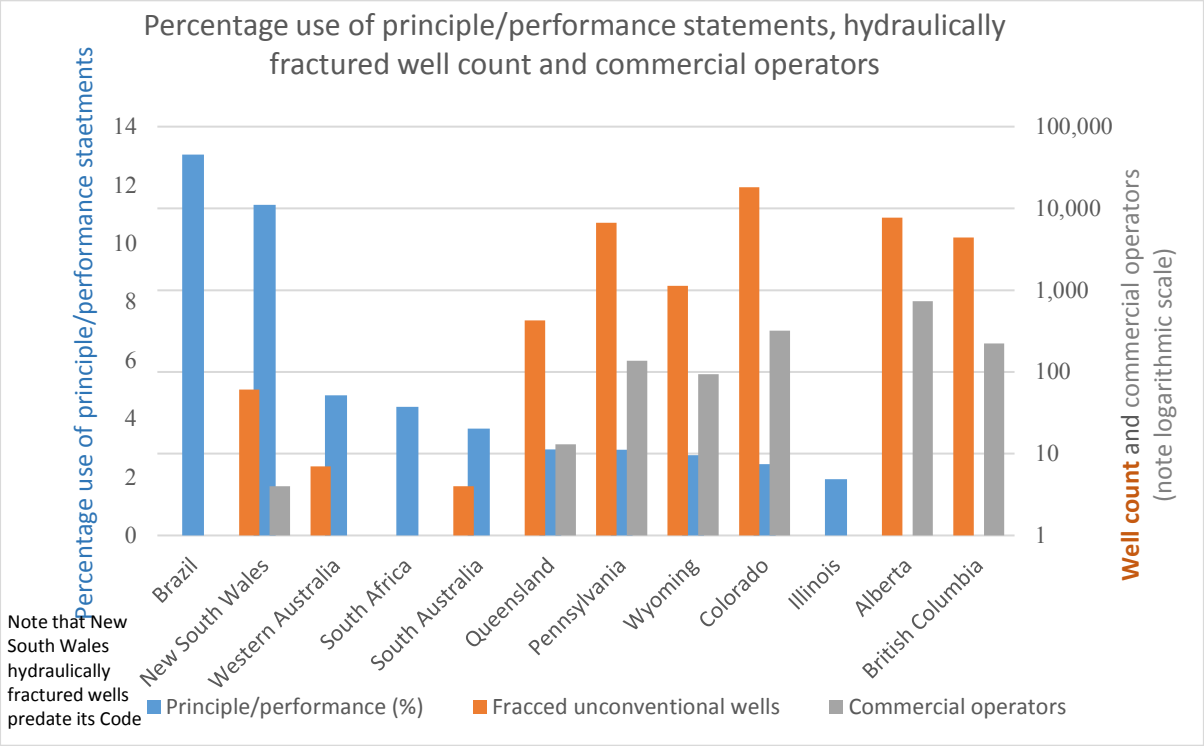

Figure 1: Unconventional well development and use of performance regulation

Using the above typology of regulatory form, regulations from the stated jurisdictions were analysed and relative proportions of performance based measured. There appears to be an inverse relationship between the use of performance regulation and petroleum development, suggesting that prescription regulation leads more frequently to resource development.

(7) 'Best practice'. The concept of a 'best practice' is one that would appear to be founded more in politics than engineering. It is a claim that could only be supported by a current detailed analysis of similar practices across the world that necessitates extensive travel and invitations to resource operations and governance structures, and on an ongoing and frequent basis. While such ambitions would be laudable, in practice it is unattainable other than through fortunate circumstances for restricted and one-off areas such as my thesis. Alternative terms reflecting consideration of practice elsewhere, local constraints and governance arrangements would be more approriate.

(8) **A review of regulatory form typologies and schema.** Many studies of legislation, taking an overarching view, examine regulatory frameworks and ascribe labels such as principle-based, management-based or process-based regimes and find evidence within the suite of regulatory statements under study that are contradictory, with inclusion of prescription and performance statements at the operational level (Black 2008, Coglianese, Nasj, and Olmstead 2003, Cunningham 2007, Deighton-Smith 2008, Gilad 2010, Hill Clarvis, Allan, and Hannah 2014, May 2007, Sinclair 1997). Such evidence may not detract from an argument that a principle-based or process-based approach is better suited to a particular paradigm. Rather, that the law makers may have had to make some pragmatic decisions in developing an overall package to succeed through regulatory approval in the political environment (Coglianese 2015). May assesses the overarching view of regulatory regimes and postulates that *Given the variety of ways that rules and standards can be crafted and responsibilities for regulatory actions can be assigned, there is no definitive categorization of regulatory regimes* (p9, May 2007). However, my research was not looking at policy regimes, rather, it considered the lowest level of regulation, each individual unit of observation referred to in this thesis as a regulatory statement, for example: *Well sites shall be designed and constructed using secondary containment,* **Pennsylvania Title 25: Chapter 78.a(64a)(a)**, wherein the clarity of purpose for that statement is not confused with higher level strategies and policy overtures. Regulatory policy is an area that has provoked much discourse, and proposals are extensive for selecting the most appropriate tool to meet the circumstances and expectations (Bennear and Coglianese 2012, Black 2008, Coglianese 2017, Deighton-Smith 2008, Freiberg 2010, Gunningham 2015, Richards 2000, Sparrow 2001, 2008, Taylor et al. 2012). The need to develop a systematic regulatory spectrum has had repeated calls, with Coglianese reporting from a 2003 workshop: *In light of these various ways to distinguish among performance standards, several participants noted the need to develop a more refined taxonomy of performance standards to avoid confusion and facilitate better decision-making. An important step for future research will be to develop a clearer conceptualization of the different types of performance standards* (p711, Coglianese, Nasj, and Olmstead 2003). And still, 14 years later, Coglianese continues to observe *The field of regulation sorely lacks a clear and widely accepted conceptual taxonomy of regulatory design, which has impeded research and unfortunately has too often clouded policy judgment* (p529, Coglianese 2017).

As an example of the way regulatory regimes can be defined and their attributes displayed, **Table 2** provides a useful assessment of elements of different regulatory regimes that has helped to inform my study (May 2007)**.** The categorisation, however, is high level and does

not provide the granularity necessary to apply to the myriad of circumstances under each regime sought to be regulated.

Table 2: Comparison of regulatory regimes showing attributes and applications (May 2007)

Aspect	**Prescriptive regulation**	**System-based regulation (*Process*)**	**Performance-based regulation**
Regulatory foci	Prescribed actions	Process or system	Results or outcomes
Compliance determination	Adherence to prescribed actions	Acceptable production system	Achievement of desired results
Nature of rules and standards	Particularistic and detailed specifications	Process-oriented specifications	Goal-oriented specifications
Basis for achieving regulatory goals	Adherence to prescriptions presumed to meet goals	Appropriate system controls are designed to meet goals	Regulatory goals are embedded in the results orientation
Examples	Dominant regulatory approach in the USA for environmental and social regulation	Aspects of food safety, industrial health and safety, nuclear power plant safety	Aspects of air and water quality, building and fire safety, energy efficiency, forest practices, pipeline safety

The descriptions provided by May suggests a spectrum with compliance matters extending from input-specified actions for prescription through to the achievement of results-related outcomes for performance-based regulatory regimes, requiring quite different compliance measures and skills. Sitting between these two regimes in **Table 2** is process based regulation. Process based regulatory statements invoke actions that are defined in high level terms to be devised and undertaken by the operator or to implement one already in existence such as a national standard or an industry code of practice, the state of compliance is reached by undertaking the action rather than achieving a particular outcome. Process based regulatory statements have close similarities to prescription in that they seek to constrain the actions of the operator in their application and they focus on input rather than outcomes.

In a review of regulatory regimes applied to the nuclear energy sector in Sweden, a survey of regulators identified key benefits and difficulties (**Table 3**) of the different regimes of regulation (Melber and Durbin 2005). Although the nuclear power sector has significantly higher consequences of risk, there is a degree of correspondence that identifies some of the benefits and drawbacks of the regimes and reinforces the need to be circumspect in suggesting that one regime or another can solely provide the tools to achieve the intended end result, particularly with a complex, multi-faceted activity such as hydraulic fracturing.

Table 3: Benefits and difficulties with regulatory strategies in the nuclear energy sector (Modified from Melber and Durbin 2005)

Benefits	Difficulties
Prescriptive strategy	
Prescriptive strategies are clear about requirements and expectations for both the licensee and the regulator	Prescriptive strategies take responsibility away from the licensee and put it on the regulator
Prescriptive strategies are useful for specified technical areas or under certain conditions	Prescriptive strategies lead to a high use of resources by the regulator
	Prescriptive strategies are inflexible, rigid and difficult to change requirements
	Prescriptive strategies discourage innovation
	Prescriptive strategies may miss some significant areas and focus on low level issues
	Regulator does not have sufficient specific knowledge to adequately develop detailed requirements for a prescriptive strategy
Outcome based strategy [Performance-based]	
Outcome based strategies allow licensees to determine best way to operate	Outcome based strategies require defining goals, outcomes, or performance indicators, which is difficult
Outcome based strategies allow innovation and changes to respond to new knowledge	Outcome based strategies do not address issues early enough
Outcome based strategies are most useful in specific areas	Outcome based strategies lead to high use of resources by both regulators and licensees
	Outcome based strategies can be associated with regulatory uncertainty
	Outcome based strategies should be used in combination with other strategies

The concept of a regulatory regime as distinct from a regulatory statement seems to add to the confusion in the literature and is succinctly summarised by Baldwin et al, when discussing risk-based regulation, notes that it should not be seen….*as a free-standing and technical guide to regulatory intervention but as a particular way to construct the regulatory agenda and as*

a control strategy that has to be combined with other control strategies in different (and often contentious) ways across different contexts and regulatory tasks (p294, Baldwin, Lodge, and Cave 2011). Cunningham also takes issue with the concept of principles-based regimes existing in isolation from rules-based (prescription) regimes when he notes that his paper:… *reviews the literature on rules and principles, showing considerable struggles concerning matters of classification and trade-offs as well as of labelling. Extending this literature from individual provisions to entire systems, discussion justifies skepticism about whether it is feasible to describe or design such system as "principles-based" or "rules-based."* (p6, Cunningham 2007).

However, the literature focusing on regulatory regimes adopt a systems approach where a particular regime is examined in detail and, not surprisingly, the researchers find anomalies:

- Comprehensive review (Freiberg 2010, Gilad 2010, May 2007, Sinclair 1997);
- Process-based (management-based) regulation (Coglianese 2010b);
- Process and performance-based regulation (Coglianese and Lazer 2003, Deighton-Smith 2008);
- Principle-based regulation (Black 2008); and
- Performance-based regulation (Coglianese, Nasj, and Olmstead 2003, Davis 2000).

These studies provide detailed review of the structure, suitable context, reasoning and abilities behind each regulatory regime.

Coglianese places four basic types of regulatory commands on an array with the axes of micro/macro and means/ends establishing their attributes shown in **Table 4**, however, the examples imply a degree of uniformity for each type of use, which is rare.

Table 4: Regulatory command array (modified from Coglianese 2010)

	Means	**Ends**
Micro	**Means-based** *(prescription)* Design standards; specification standards; technology-based regulation; command and control regulation	**Performance-based** *(performance)* Outcome-based regulation; market-based regulation.
Macro	**Management-based** *(process)* Process or systems regulation; safety case regulation; risk-management regulation; enforced self-regulation; meta regulation	**Meta-performance** *(principle)* Ex post liability; general duty clause

(9) **Regulatory form.** In undertaking this analysis of nearly 2,000 regulatory statements, occasionally, the structure of a statement was found to be complex, verbose or confusing where only through following a tight definition, could the category be determined. The application of the term "regulatory statement" in this research helps in the clarification by avoiding the term "regulation", that is variously used to describe an individual legal clause or a conceptual package of policies, as noted in the Oxford Dictionary:[1]

Regulation:-

[noun] *rule or directive made and maintained by an authority. Eg. 'planning regulations'*

[1] https://en.oxforddictionaries.com/definition/regulation, 24/01/2018

[mass noun] *the action or process of regulating or being regulated. Eg. 'the regulation of financial markets'.*

The full typology used in this study is set out in **Table 5** to differentiate regulatory statements at the unit of observation (sentence) level. In order to provide clarity, the definitions are detailed in terms of grammatical structure rather than policy intent.

Table 5: Regulatory statement form typology

Regulatory statement form	**Definition**
Group form Prescriptive **(What to do)**	*A regulatory statement, statement or legislative instrument that specifies in relatively precise terms what is to be done* (p89, Freiberg 2010)
Prescriptive: power	A regulatory statement conferring a power on a party, conferring an order or providing for withholding an action
Prescriptive: responsibility	A regulatory statement conferring a behavioural responsibility on a party
Prescriptive: prohibition	A regulatory statement prohibiting an activity or state
Prescriptive: exemption	A regulatory statement exempting the specified party from undertaking a particular action
Prescriptive: liability or defence	A regulatory statement conveying: liability due to specified circumstances; or, defined elements of defence
Prescriptive: mandate	A regulatory statement requiring attainment of, or the conferring of, a specified mandate or approval
Prescriptive: evidence, discovery or notification	A regulatory statement requiring: the supply of evidence that could include a plan; the discovery of knowledge; or notification to a party
Prescriptive: action	A regulatory statement requiring a specified action or compliance with a regulatory statement.
Prescriptive: specification	A regulatory statement establishing a specification (numeric or narrative) for compliance.
Group form Process-based **(How to do it)**	*Management-based approaches intervene at the planning stages, compelling the regulated organizations to improve their internal management so as to increase the achievement of public goals.* (Coglianese and Lazer 2003)
Process: authority	A regulatory statement requiring the implementation of a targeted, published authority to achieve compliance (e.g. An environmental management plan conforming to ISO14001)
Process: party-plan	A regulatory statement requiring the implementation of a targeted, party-developed plan to achieve compliance (e.g. a risk management plan). The party may be the operator or another party with relevant skills.

Regulatory statement form	Definition
Group form Principle-based **(How to do it and where to get to)**	*Principle-based regulation describes the method of achieving a regulatory outcome by setting a general objective of standard, or describing a general duty, but without specifying the means of achieving that outcome, leaving it to other bodies to interpret the meaning or principle in particular context. Principle-based regulation is outcome-oriented rather than process driven.* (p92, Freiberg 2010) Principle-based regulatory statements include two elements: a process and an outcome
Principle: authority - qualitative	A regulatory statement: requiring the implementation of a published authority; and nominating a qualitative or narrative outcome to be achieved
Principle: party-plan - qualitative	A regulatory statement: requiring the implementation of a party-developed plan; and nominating a qualitative or narrative outcome to be achieved
Principle: authority-quantitative	A regulatory statement: requiring the implementation of a published authority; and nominating a quantitative outcome to be achieved
Principle: party-plan - quantitative	A regulatory statement: requiring the implementation of a party-developed plan; and nominating a quantitative outcome to be achieved
Group form Performance-based **(Where to get to)**	*Performance-based regulation specifies desired outcomes or objectives, but not the means by which they must be met* (para 1.27, Victorian Law Reform Committee 1997 from Freiberg 2010) *A performance standard specifies the outcome required but leaves the specific measures to achieve that outcome up to the discretion of the regulated entity* (Coglianese, Nasj, and Olmstead 2003)
Performance: qualitative	A regulatory statement requiring a qualitative or narrative outcome to be achieved. [For example, a healthy waterway.]
Performance: quantitative	A regulatory statement requiring a quantitative outcome to be achieved. [For example, USEPA Aquatic Life Ambient Water Quality Criteria.]

(10) **Regulatory statement form typology and examples.** The regulatory form typology advanced in this thesis categorised 1,921 regulatory statements. The following examples draw out salient features of each of the categories.

(10.1) Prescription:power

A regulatory statement conferring a power on a party, conferring an order or providing for withholding an action.

The policy intent of the regulatory statement is a major determinant in deciding the form of the statement. In certain areas of the administrative parts of the regulatory regime, the conferring of power requires prescription to be meaningful and clear. In these following cases power is allocated in three different ways. In the first, the director can, at their discretion, order a particular party to act; in the second, any person may commence a civil action; and in the third, best management practices are given status.

British Columbia EMA.79.3: *If an escape or spill occurs of a polluting substance for which a contingency plan was prepared, a director may order any person having possession, charge or control of the substance at the time it escaped or was spilled, or the person who prepared the plan or all of them to put the contingency plan into operation at their expense.*

Illinois S1-102(b)(part 1): *Any person having an interest that is or may be adversely affected may commence a civil action against the Department on his or her own behalf to compel compliance with this Act where there is alleged a failure of the Department to perform any act or duty under this Act that is not discretionary with the Department.*

Pennsylvania 78.a(53)(part 2): *Best management practices for erosion and sediment control and stormwater management for oil and gas operations are listed in the Erosion and Sediment Pollution Control Program Manual, Commonwealth of Pennsylvania, Department of Environmental Protection, No. 363-2134-008, as amended and updated, the Pennsylvania Stormwater Best Management Practices Manual, Commonwealth of Pennsylvania, Department of Environmental Protection, No. 363-0300-002, as amended and updated, the Oil and Gas Operators Manual, Commonwealth of Pennsylvania, Department of Environmental Protection, No. 550-0300-001, as amended and updated, and Riparian Forest Buffer Guidance, Commonwealth of Pennsylvania, Department of Environmental Protection, No. 395-5600-001, as amended and updated.*

(10.2) Prescription:responsibility

A regulatory statement conferring a behavioural responsibility on a party.

Prescription:responsibility regulatory statements place a behavioural demand on the Attribute. In the first example, responsibility may extend beyond the operator to a neighbouring well owner who could be regarded as an involuntary and possibly unwilling participant. In the second example, the statement requires the operator to provide appropriate training to specified recipients. The third example places an unequivocal requirement on a person as the result of an order having been so directed. The fourth example requires the Commission to respond in a timely fashion following the submission of information. The final example conveys responsibility to the implicit Attribute, the well operator.

Alberta 083(14)(part 2): *Upon notification of a planned hydraulic fracturing program, licensees of at-risk offset wells are expected to engage and work cooperatively with licensees of subject wells in the development of well control plans.*

Brazil Article 24 (part 1): *The Operator shall ensure that the workforce is adequately trained to perform its functions and understands the risks identified in the Risk Analysis performed for the project.*

British Columbia EMA.85.8: *Despite any other enactment, a person to whom an order under subsection (3) or (5) is expressed to apply must comply with the order.*

Colorado 205A(b)(3)(B)(part 2): *As soon thereafter as practicable, the Commission shall make such forms available on the Commission's website in a manner that allows the public to search the information and sort the forms by geographic area, ingredient, chemical abstract service number, time period and operator, as practicable.*

Pennsylvania 78.a(59b)(a): *In addition to meeting the requirements of § 78a.59a (relating to impoundment embankments), any new well development impoundments must be in compliance with this section.*

(10.3) Prescription:prohibition

A regulatory statement prohibiting an activity or state

Prescription:prohibition regulatory statements are typically short and direct and may look to avoid an outcome (first example) or avoid a practice that may have adverse risk that the regulator wishes to avoid condoning (second example). They are usually very explicit.

Alberta 083(18): *Licensees' hydraulic fracturing operations must not have an adverse effect on a nonsaline aquifer.*
Alberta 083(26): *Licensees must not initiate nitrogen fracturing operations within a zone that extends 200 m horizontally from the surface location of a water well to 50 m vertically from the total depth of the water well.*

(10.4) Prescription:exemption

A regulatory statement exempting the specified party from undertaking a particular action.

The prescription:exemption may be applied unconditionally such as the first example where a legal requirement to be truthful in the conveyance of information, often subject to the possible penalty of incarceration, is suspended as the truthfulness is out of direct control of the service provider. In the second case, where other matters that may be subject to public availability, the information disclosed is exempted from such availability. In the third example, the Lieutenant Governor-in-Council has the discretion to overpower other regulation by exempting its effect. The forth example includes a number of conditions to be met and then the exemption may have effect without further intervention by any decision maker. Distinct from prescription:prohibition statements, the prescription:exemption statements may be more extensive and include conditions qualifying its application.

Colorado 205A(b)(4)(part 2): *A service provider is not responsible for any inaccuracy in information that is provided to the service provider by the vendor.*
Illinois S1-77(l)(part 4): *Information so disclosed to a health professional shall in no way be construed as publicly available.*
British Columbia O&GAA 105(1): *In making a regulation under section 103, the Lieutenant Governor in Council may provide an exception to the application of the regulation, including an exception relating to the application of an environmental measure.*
Pennsylvania 78.a(67)(a)(part 2): *The mining permit exemption only applies so long as the borrow pit is servicing an oil and gas well site where a well is permitted under section 3211 of the act (relating to well permits) or registered under section 3213 of the act (relating to well registration and identification) and the requirements of section 3225 of the act (relating to bonding) are satisfied by filing a surety or collateral bond for wells drilled on or after April 18, 1985.*

(10.5) Prescription:liability or defence

A regulatory statement conveying: liability due to specified circumstances; or, defined elements of defence.

The use of the prescription:liability or defence regulatory statement is infrequent, constituting only 3.3% of the dataset but their use may depend on the approach taken by the jurisdiction to enforcement. Rather than have the punitive action placed within the regulatory

statement, such punitive action may be located in a single area of the act as is the case with **Illinois S1-100** or such power may be located in another statute altogether. The use of strict liability, as in the case with examples two and three, provides a strong incentive for the operator to remain on the right side of the law, it also sends clear message to the public that the legislation has unequivocal powers. The regulatory statement may also extend the impact of liability as in the fourth example. In respect to defence, the regulatory statement may provide an argument even if it may have to be argued in court, as shown with the last example.

Illinois S1-100(b)(part 1): *It is unlawful for a person knowingly to violate:*
(1) subsection (c) of Section 1-25 of this Act;
(2) subsection (d) of Section 1-25 of this Act;
(3) subsection (a) of Section 1-30 of this Act;
(4) paragraph (9) of subsection (c) of Section 1-75 of this Act; or
(5) subsection (a) of Section 1-87 of this Act.

British Columbia EMA.79.6: *In a prosecution for a contravention of subsection (5), it is presumed that the accused knew of the escape, spill or introduction at the time of the alleged contravention and the burden of proving that he or she did not know is on the accused.*

Western Australia PGER(E)Reg.6: *The operator of an activity commits an offence if —*
(a) the operator carries out the activity; and
(b) there is no environment plan for the activity.
Penalty: a fine of $10 000.

British Columbia EMA.88.5: *For the purpose of subsection (3), anything done or omitted by a person acting in the course of the person's employment is also the act or omission of the person's employer.*

Western Australia PGER(E)R 38.2: *It is a defence to a prosecution for an offence against sub-regulation (1) if the operator has a reasonable excuse.*

(10.6) Prescription:mandate

A regulatory statement requiring attainment of, or the conferring of, a specified mandate or approval.

The form of regulatory statements dealing with prescription:mandate tend to be straightforward and unequivocal. In the following examples, a mandate may be verbal or documented by the responsible agency, or as in the last case, granted by another arm of government.

Alberta 083(11)(part 2): *The use of high vapour pressure hydrocarbons requires prior approval by the ERCB pursuant to section 8.110 (3) of the Oil and Gas Conservation Regulations.*

Brazil Article 19 (part 1): *The high pressure lines used in Hydraulic Fracture in a Non-Conventional Reservoir must be certified for their integrity, within the expiration date and be tested before each operation.*

Colorado 317(d)(part 3): *During well operations, prior verbal approval for unforeseen casing repairs followed by the filing of a Sundry Notice, Form 4, after completion of operations shall be acceptable.*

Wyoming Chapter 3 46.e(part 7): *Previously sampled water sources, including samples obtained by other operators, may be used if collection of the sample or samples meet all of the requirements of this rule and are approved by the Supervisor by Sundry Notice (Form 4).*

South Africa S123(1): *A holder must, prior to commencement of hydraulic fracturing, obtain the necessary authorisation for the water uses as required, indicating the supply source,*

quality and location for the base fluid for each stage of the operation and the water usage volume.

(10.7) Prescription:evidence/discovery/notification

A regulatory statement requiring: the supply of evidence that could include a plan; the discovery of knowledge; or notification to a party.

The supply of evidence or information is a commonplace requirement of regulatory regimes. Three circumstances of prescription:evidence/discovery/notification are noted in the first example: reporting a blowout, developing a risk assessment (discovery) and preparing a risk mitigation plan. The second example requires the submission of a plan if the Minister is not fully informed. The third example requires the use of an authority (**API RP 10 B-2**) to develop evidence for submission. The fourth example includes a punitive element for failing to comply.

Alberta Directive 008(2)(21): *If an uncontrolled water flow is encountered (a blowout, as defined in Directive 036)*
a) the blowout must be reported to the appropriate AER field centre,
b) a risk assessment must be conducted to determine if an additional string of casing is required, and
c) approval must be obtained from the appropriate AER field centre before the licensee proceeds with drilling operations.
Note: Reporting requirements for blowouts are set out in Directives 036 and 059.
The AER expects licensees to take precautions to ensure that the water flow is controlled and the aquifer is protected during the drilling operation.
British Columbia EMA.78: *If the minister considers that*
(a) something a person proposes to do will have a detrimental environmental impact, and
(b) the environmental impact cannot be assessed from information available to the minister, the minister may require the person to provide an environmental impact assessment in respect of that thing, prepared in accordance with the regulations.
South Africa S102(7): *Test data showing competency of a proposed cement mixture to meet the requirements of the current API "API RP 10 B -2 Recommended Practice for Testing Well cements" must be submitted to the designated agency for approval prior to the cementing operation.*
Western Australia PGER(E)Reg.11.7: *Within 10 days after receiving a notification that the Minister has approved an environment plan under subregulation (5)(a), the operator must submit to the Minister for public disclosure a summary of the plan.*
Penalty: a fine of $5 500.

(10.8) Prescription:action

A regulatory statement requiring a specified action or compliance with a regulatory statement.

The commonly understood term “command and control” resonates closely with the prescription:action regulatory statement where the subject (Attribute) is required to undertake some tangible action. The actions and the prevailing circumstances required, are tightly defined for the statement to be invoked. In the first example, search criteria (area and circumstances) and response actions are specified. The second and third are similar to the first, requiring action after becoming aware of an event. The fourth requires the director to undertake action under certain conditions. The fifth example directs what must or may be included in the statement of environmental objectives.

Alberta Directive 008(2)(19): *The licensee must search a 1 km radius from the surface location of the proposed well and use a conductor pipe and a Class I BOP system if there are:*
a) offset wells that indicate water flows, or
b) springs or flowing seismic shot holes (see Environment and Sustainable Resource Development water well database).
Alberta 083(32): *Licensees of the subject well must immediately notify the appropriate ERCB field centre upon becoming aware of any communication event with an offset well, a non-saline aquifer, or a water well.*
British Columbia EMA.77.3: *Information required by an order under this section must be provided in the time and manner specified in the order.*
Colorado 903(e)(part 1): *The Director shall endeavour to review any properly completed Earthen Pit Report/Permit, Form 15, within thirty (30) calendar days after receipt.*
South Australia P&GEA 100.3 (part 1): *A statement of environmental objectives—*
(a) may provide for and, for high impact activities, must provide for a report or periodic reports (to be obtained by the Minister at the expense of the licensee) from an independent expert on the environmental consequences of the activities; and
(b) may include a system for evaluating the licensee's environmental performance.

(10.9) Prescription:specification

A regulatory statement establishing a specification (numeric or narrative) for compliance.

Prescription:specification regulatory statements leave little room to doubt as to what is the intention of the law drafter. The first and second examples spell out in minute detail the expectations for compliance. The third is much briefer but provides for various circumstances (single or multiple wells). The fourth regulatory statement adopts a complete cover by not only specifying a suite of authorities from the National Incident Management System planning standards but then continues to list individual requirements. The fifth and sixth statements use the curious phrase “avoidance/remove doubt” as a panacea to misinterpretation that was not achieved at the previous regulatory statement. In the first case, even more doubt is cast as the statement only excludes certain conditions, allowing for a range of other, possibly less satisfactory measurement approaches. In the second use of the term, absolute clarity is established.

Illinois S1-70(d)(8): *Cement compressive strength tests must be performed on all surface, intermediate, and production casing strings; after the cement is placed behind the casing, the operator shall wait on cement to set until the cement achieves a calculated compressive strength of at least 500 pounds per square inch, and a minimum of 8 hours before the casing is disturbed in any way, including installation of a blowout preventer. The cement shall have a 72-hour compressive strength of at least 1,200 psi, and the free water separation shall be no more than 6 milliliters per 250 milliliters of cement, tested in accordance with current American Petroleum Institute standards.*
Illinois S1-75(f)(part 4): *The high volume horizontal hydraulic fracturing operations completion report shall contain the following information:*
(1) the permittee name as listed in the permit application;
(2) the dates of the high volume horizontal hydraulic fracturing operations;
(3) the county where the well is located;
(4) the well name and Department reference number;
(5) the total water volume used in the high volume horizontal hydraulic fracturing operations of the well, and the type and total volume of the base fluid used if something other than water;

(6) each source from which the water used in the high volume horizontal hydraulic fracturing operations was drawn, and the specific location of each source, including, but not limited to, the name of the county and latitude and longitude coordinates;
(7) the quantity of hydraulic fracturing flowback recovered from the well;
(8) a description of how hydraulic fracturing flowback recovered from the well was disposed and, if applicable, reused;
(9) a chemical disclosure report identifying each chemical and proppant used in hydraulic fracturing fluid for each stage of the hydraulic fracturing operations including the following:
(A) the total volume of water used in the hydraulic fracturing treatment of the well or the type and total volume of the base fluid used in the hydraulic fracturing treatment, if something other than water;
(B) each hydraulic fracturing additive used in the hydraulic fracturing fluid, including the trade name, vendor, a brief descriptor of the intended use or function of each hydraulic fracturing additive, and the Material Safety Data Sheet (MSDS), if applicable;
(C) each chemical intentionally added to the base fluid, including for each chemical, the Chemical Abstracts Service number, if applicable; and
(D) the actual concentration in the base fluid, in percent by mass, of each chemical intentionally added to the base fluid;
(10) all pressures recorded during the high volume horizontal hydraulic fracturing operations; and
(11) any other reasonable or pertinent information related to the conduct of the high volume horizontal hydraulic fracturing operations the Department may request or require by administrative rule.
Pennsylvania 78.a(55)(i)(3)(ii): *The operator shall determine the GPS coordinates for both the well site and the entrance to the well site. The GPS coordinates must have a horizontal accuracy of plus or minus 6.67 feet or better. If there is more than one well on a well site, one set of GPS coordinates must be used for the well site.*
Pennsylvania 78a.55(i)(5)(i)[part b]: *The plan shall incorporate National Incident Management System planning standards, including the use of the Incident Command System, Incident Action Planning and Common Communications Plans. The plan must include:*
(A) The emergency contact information, including phone numbers, for the well operator's local representative for the well site and the well operator's 24-hour emergency phone number.
(B) The emergency notification procedures that the operator shall utilize to contact emergency responders during an emergency.
(C) A description of the well site personnel's response to the following well site emergencies:
(I) Fire.
(II) Medical emergency.
(III) Explosion or similar event.
(IV) Spill.
(V) Security breach or other security event.
(VI) Any other incident that necessitates the presence of emergency responders.
(D) A description of the procedure to be used to provide the most current information to emergency responders in the event of an emergency, including the following:
(I) The current Material Safety Data Sheet (MSDS) required under law to be present at the well site.
(II) The location of the MSDSs at the well site.

(III) The name of the position in the operator's organization responsible for providing the information in sub clauses (I) and (II).

(E) A list containing the location of any fire suppression and spill control equipment maintained by the well operator at the well site.

(F) A description of any emergency equipment available to the operator that is located off of the well site.

(G) A summary of the risks and hazards to the public within 1/2 mile of the well site and the associated planning assumptions.

(H) An outline of the emergency response training plan that the operator has established.

(I) the location of and monitoring plan for any emergency shutoff valves located along temporary pipelines in accordance with § 78a.68b (relating to temporary pipelines for oil and gas operations).

Queensland EPR 81B.3: *To remove any doubt, it is declared that the amount of a chemical mentioned in subsection (1) or (2) is not measured in relation to water included in the restricted stimulation fluid.*

Western Australia PGER(E)Reg.14.4: *For the avoidance of doubt, the evaluation mentioned in subregulation (3)(b) must evaluate all the environmental impacts and environmental risks arising directly or indirectly from —*

(a) all aspects of the activity; and

(b) potential emergency conditions, whether resulting from accident or any other cause.

(10.10) Process:authority

A regulatory statement requiring the implementation of a targeted, published authority to achieve compliance.

Due to the calling-in of external authorities such as standards, acts or agency codes, process:authority regulatory statements tend to be brief as is shown in each of the four examples below. The constraint applied through the use of external authorities may be relatively narrow as the case of Alberta and Illinois or much more extensive and complex with the examples of Brazil and Colorado. The entire regulatory statement of Colorado quoted here, however, is redundant as the action is required under other acts and instruments, no value or added requirement is evident. The risk involved with using a process:authority regulatory statement is for a change to the authority being promulgated that may have impacts not contemplated by the regulator and for them not to be aware of the change.

Alberta Directive 008(2)(1): *Surface casing must be designed in accordance with this section, and the surface casing depth must be used in the well license application (see Directive 056: Energy Development Applications and Schedules).*

Brazil Article 26: *The requirements of Item 9 - Emergency Plan of the Technical Regulation of the Structural Integrity Management System for Land and Oil Production Ground Installations - SGI annexed to ANP Resolution No. 02/2010, shall apply, whichever is applicable.*

Colorado 906(b)(6): *Chemical spills and releases shall be reported in accordance with applicable state and federal laws, including the Emergency Planning and Community Right-to-Know Act, the Comprehensive Environmental Response, Compensation, and Liability Act, the Oil Pollution Act, and the Clean Water Act, as applicable.*

Illinois S1-70(d)(2): *Casing thread compound and its use must conform to the current industry standards published by the American Petroleum Institute.*

(10.11) Process:party plan

A regulatory statement requiring the implementation of a targeted, party-developed plan to achieve compliance.

A process:party plan regulatory statement has the essential element of a plan developed by a party, not necessarily the operator, and for it to be implemented. Compliance is achieved by developing and implementation rather than other measures such as what the effect of the action may produce. Process:party plan statements are quite commonplace and require the Attribute to invest in its development rather than to take a tick-the-box approach of following prescription. Process regulatory statements have similarities with prescription, in their relatively precise detail of expectations. The first example deals with safety and emergency response plans, requiring submission to the Department. The South Australian example appears to be a principle:party plan/qualitative statement but the last subclause (f) fails to establish any measureable performance outcome and, hence, it is categorised here. The last example shows the development of plans with support from external persons including a need to prove competency of the person.

Illinois S1-35(b)(12): *Every applicant for a permit under this Act must submit the following information to the Department on an application form provided by the Department: a well site safety plan to address proper safety measures to be employed during high volume horizontal hydraulic fracturing operations for the protection of persons on the site as well as the general public. Within 15 calendar days after submitting the permit application to the Department, the applicant must provide a copy of the plan to the county or counties in which hydraulic fracturing operations will occur.*

South Australia P&GER 13.1: *A statement of environmental objectives must include objectives that relate to the following matters:*

(a) construction activities;

(b) operational activities;

(c) emergency response and management;

(d) rehabilitation in cases involving a serious incident or reportable incident under section 85 of the Act;

(e) decommissioning, abandonment and rehabilitation;

(f) dealing with the consequences of events associated with the relevant activities on the various aspects of the environment.

Wyoming Chapter 3 22.e.i: *In addition, the following requirements apply to all wells drilled within the Special Sodium Drilling Area – A (SSDA – A), as defined in Chapter 1, Section 2(tt) of these rules, unless altered, modified, or changed for a particular well, pool, unit, area or lands upon hearing before the Commission:*

(i) Any oil or gas wells that will be drilled within the area of influence of underground trona mining shall be:

(A) Designed and installed to withstand the forces and potentially damaging influences from mining as certified by a Registered Professional Engineer registered in the state of Wyoming or

(B) Demonstrated to be located outside the mining influence area.

Mining influence includes surface subsidence and underground formation collapse, faulting fracturing and related stresses that may provide avenues for communication with active or inactive underground mine works, open mine voids, and corrosive mine fluids that may cause well casing corrosion or failure as a result of mining.

(10.12) Principle:authority-qualitative

A regulatory statement: requiring the implementation of a published authority; and nominating a qualitative or narrative outcome to be achieved.

The principle:authority-qualitative regulatory statements tend to rely on general descriptions of aspects of the environment and its qualities. The authorities called upon may be publications produced by the agency (New South Wales, Pennsylvania and Wyoming) or external authorities (American Petroleum Institute for Illinois).

Illinois S1-70(d)(4): *Cement must conform to current industry standards published by the American Petroleum Institute and the cement slurry must be prepared to minimize its free water content in accordance with the current industry standards published by the American Petroleum Institute; the cement must also:*
(A) secure the casing in the wellbore;
(B) isolate and protect fresh groundwater;
(C) isolate abnormally pressured zones, lost circulation zones, and any potential flow zones including hydrocarbon and fluid-bearing zones;
(D) properly control formation pressure and any pressure from drilling, completion and production;
(E) protect the casing from corrosion and degradation; and
(F) prevent gas flow in the annulus.
New South Wales Stimulation Code 13.2(b): *The titleholder must ensure that fracture stimulation activities are conducted in a manner which:*
i. complies with this Code, relevant Government policies, approval conditions, title conditions and legislative requirements
ii. manages all health, safety and environmental risks associated with the fracture stimulation process
iii. uses all reasonable endeavours to ensure the fracture stimulation is contained within the targeted area
iv. uses all reasonable endeavours to ensure that fractures do not induce connections with water sources
v. uses all reasonable endeavours to avoid pollution of water sources
vi. puts in place appropriate monitoring, response plans and reporting regimes to ensure that any risk to health, safety or the environment can be promptly addressed or mitigated
Pennsylvania 78.a(54): *The well operator shall control and dispose of fluids, residual waste and drill cuttings, including tophole water, brines, drilling fluids, drilling muds, stimulation fluids, well servicing fluids, oil, production fluids and drill cuttings, in a manner that prevents pollution of the waters of the Commonwealth and in accordance with §§ 78a.55—78a.58 and 78a.60—78a.63 and with the statutes under which this chapter is promulgated.*
Wyoming Chapter 3 45.j(part 3): *If lined pits are utilized to store fluid for use in well stimulation, or for reconditioning, for reuse, or to hold for appropriate disposal, then the requirements of Chapter 4, Section 1 of these rules shall be met to protect wildlife and migratory birds.*

(10.13) Principle:party plan-qualitative

A regulatory statement: requiring the implementation of a party-developed plan; and nominating a qualitative or narrative outcome to be achieved.

Principle:party plan-qualitative regulatory statements were the most frequent form of performance based regulation found in this study at 2.5% frequency. The construct of the statements tend to be imprecise in respect to compliance likelihood and similarly, the statements are very open as to how the actions are to be fulfilled, however, **Western**

Australia PGER(E)Reg.11.1 illustrates the facets of a principle:party plan-qualitative regulatory statement that achieves testability. Content and development process of the party-plan authority is stipulated in (a), (b), (c), (e), (f) and (g) and the qualitative performance is established in (d). The absence of specified environmental performance standards in (d) could give rise to concern, however, the requirement for the Minister to approve the plan allows adequate opportunity to canvass a range of applicable numeric or qualitative standards or reject the plan, if not meeting the Minister's satisfaction.

Western Australia PGER(E)Reg.11.1: *The Minister must approve the environment plan if the Minister is reasonably satisfied that the plan —*
(a) is appropriate for the nature and scale of the activity; and
(b) demonstrates that the environmental impacts and environmental risks of the activity will continuously be reduced to as low as is reasonably practicable; and
(c) demonstrates that the environmental impacts and environmental risks of the activity will be of an acceptable level; and
(d) provides for appropriate environmental performance objectives, environmental performance standards and measurement criteria; and
(e) includes an appropriate implementation strategy and monitoring, recording and reporting arrangements; and
(f) for the requirement mentioned in regulation 17(1)(b) — demonstrates that there has been an appropriate level of consultation with relevant authorities and interested persons and organisations; and
(g) complies with Division 3.

Brazil Article 10: *The specifications for well design and Hydraulic Fracture in a Non-Conventional Reservoir must identify the related risks in order to ensure integrity throughout the Well Life cycle, including after abandonment.*

Colorado 317(d)(part 1): *The casing program adopted for each well must be so planned and maintained as to protect any potential oil or gas bearing horizons penetrated during drilling from infiltration of injurious waters from other sources, and to prevent the migration of oil, gas or water from one (1) horizon to another, that may result in the degradation of ground water.*

New South Wales Stimulation Code 1.2(c): *The Fracture Stimulation Management Plan must demonstrate that all risks to the environment, existing land uses, the community and workforce, as a result of the fracture stimulation activity, are managed through an effective risk management process that includes identification of hazards, assessment of risks, implementation of control measures and monitoring of the integrity and effectiveness of the control measures.*

Pennsylvania 78a.66.b.3: *The operator or other responsible party shall take necessary interim corrective actions to prevent:*
(i) The regulated substance from polluting or threatening to pollute the waters of the Commonwealth.
(ii) Damage to property.
(iii) Impacts to downstream users of waters of the Commonwealth.

South Australia P&GEA 95.1(part 1): *The object of this Part is to ensure that, in carrying out regulated activities, licensees—*
(a) ensure that regulated activities that have (actually or potentially) adverse effects on the environment are properly managed to reduce environmental damage as far as reasonably practicable; and

(b) eliminate as far as reasonably practicable risk of significant long term environmental damage; and
(c) ensure that land adversely affected by regulated activities is properly rehabilitated.

(10.14) Principle:authority-quantitative

A regulatory statement: requiring the implementation of a published authority; and nominating a quantitative outcome to be achieved.

The principle:authority-quantitative regulatory statement would appear to be a preferred option if it is the intention to pursue a performance-based compliance pathway. The example below (the single example found) demonstrates great clarity in respect to what elements are called in, when required, the performance level, certification required, and the measurement methodology. It is noteworthy to identify **Illinois S1-75(e)(9)(part 1)** as not conforming to May's observation that *Regulated entities take the lead in determining compliance whereas traditionally regulatory enforcement personnel perform this function* (p4, May 2010). The law drafter has specified the performance standard for the flare to meet, which would require an emission testing regime consistent with prescriptive standards. The statement is not prescriptive as the technology is open for choice as the Illinois Hydraulic Fracturing Regulatory Act (Section 1-5 Definitions) defines: *"Flare" means a thermal oxidation system using an open, enclosed, or semi-enclosed flame,* and the performance of the different types of thermal oxidation systems vary widely dependent upon gas composition, flow rates, turn down and connected process operations. Had the law drafter wished to be more prescriptive they could have required that the flare should comply with *API STD 537: Flare details for petroleum, petrochemical and natural gas industries.*

Illinois S1-75(e)(9)(part 1): *On or after July 1, 2015, all flares used under paragraphs (5) and (8) of this subsection (e) shall (i) operate with a combustion efficiency of at least 98% and in accordance with 40 CFR 60.18; and (ii) be certified by the manufacturer of the device.*

(10.15) Principle:party plan-quantitative

A regulatory statement: requiring the implementation of a party-developed plan; and nominating a quantitative outcome to be achieved.

Surprisingly, principle:party plan-quantitative regulatory statements were not found.

(10.16) Performance:qualitative

A regulatory statement requiring a qualitative or narrative outcome to be achieved.

Effective[2] performance:qualitative regulatory statements are challenging to construct due to the inherent imprecision of a qualitative narrative, such that tests of compliance are difficult or impossible to prosecute. However, the use of performance regulatory statements can operate satisfactorily where measureable data can be obtained and the achievement of the objectives can be assessed against related criteria, such as **Illinois S1-95(c)(part 1)** where agronomic data, economic history and photographs could contribute to the pre-operation benchmarks. For **South Africa S122(1)** adequate pre-drilling water quality data must be accumulated to demonstrate a lack of impact, this may be somewhat problematic as the alleged adverse impacts may occur at some distance from the source and where ambivalent or contradictory data may be present (Wyoming Department of Environmental Quality 2016).

[2] The concept of effectiveness, in respect to regulation, has a number of dimensions, relating the behaviour of the operator to the intent and spirit of the regulation and the ability of the regulator to intervene as the representative of the public interest, in seeking compliance.

The latter three examples all have lofty aims and objectives but no reference to their testability.

Illinois S1-95(c)(part 1): *For well sites where high volume horizontal hydraulic fracturing operations were permitted to occur, the operator shall restore any lands used by the operator other than the well site and production facility to a condition as closely approximating the pre-drilling conditions that existed before the land was disturbed for any stage of site preparation activities, drilling, and high volume horizontal hydraulic fracturing operations.*

South Africa S122(1): *A holder must, prior to and during all the phases of drilling and hydraulic fracturing operations, ensure that the operation does not pollute a water resource or reduce such a resource and where such an incident occurs, a holder must implement the necessary remedial measures;*

Illinois S1-75(a)(2): *All phases of high volume horizontal hydraulic fracturing operations shall be conducted in a manner that shall not pose a significant risk to public health, life, property, aquatic life, or wildlife.*

Pennsylvania 78a.69.b.1: *A WMP* [Water Management Plan] *must meet the following requirements:*

(1) Protect instream flow.
(2) Prevent adverse effects on quantity and quality of water available to other users.
(3) Protect and maintain designated and existing uses of water sources.
(4) Prevent adverse impacts to water quality in the watershed considered as a whole.
(5) Protect groundwater resources including nearby water wells.
(6) Provide for water reuse.

South Australia P&GEA 95.1 (part 2): *The object of this Part is to ensure that, in carrying out regulated activities, licensees—*

(b) eliminate as far as reasonably practicable risk of significant long term environmental damage; and
(c) ensure that land adversely affected by regulated activities is properly rehabilitated.

(10.17) Performance:quantitative

A regulatory statement requiring a quantitative outcome to be achieved.

Performance:quantitative regulatory statements were not found in this study that was somewhat surprising given the use of national and state environmental ambient criteria for other aspects of regulating the oil and gas sector, for example applying the US National Recommended Water Quality Criteria to coalbed methane produced water[3] outfalls (discharge points)[4].

(11) **Regulatory statement form applied.** The application of the various regulatory forms are shown in **Table 6**, where for each jurisdiction the absolute number and their percentage for each form applied to hydraulic fracturing regulation is indicated. The overwhelming use of prescription is reflected in the total of 96.7% of regulatory statements defined as prescription or process.

[3] Produced water is the water that is produced from the formation and returns to the surface with the hydrocarbon. It may be sourced from the water that was in contact with the formation when that was laid down millions of years ago, in which case it is called connate water. For coalbed methane, the water may be part of a broader regional aquifer and be of more recent origin.

[4] https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table#table (3/3/18)

Table 6: Regulatory statement form number and frequency across jurisdictions

Jurisdiction	N=	Prescription	Process	Principle	Performance
Alberta	63	45 (71%)	18 (29%)	-	-
Brazil	69	48 (70%)	12 (17%)	8 (12%)	1 (1%)
British Columbia	100	98 (98%)	2 (2%)	-	-
Colorado	164	154 (94%)	5 (3%)	5 (3%)	-
Illinois	363	342 (94%)	14 (4%)	5 (1%)	2 (1%)
New South	53	35 (66%)	12 (23%)	6 (11%)	-
Pennsylvania	477	418 (87%)	45 (10%)	10 (2%)	4 (1%)
Queensland	68	64 (94%)	2 (3%)	2 (3%)	-
South Africa	227	188 (83%)	29 (13%)	10 (4%)	-
South Australia	82	70 (85%)	9 (11%)	1 (1%)	2 (2%)
Western	146	137 (94%)	2 (1%)	7 (5%)	-
Wyoming	109	101 (92%)	5 (5%)	3 (3%)	-
Total	1,921	1,700 (88.5%)	157 (8.2%)	55 (2.8%)	9 (0.5%)

Hydraulic fracturing regulatory statement form data are shown in **Figure 2**, ranked by the proportion of principle and performance-based forms, increasing toward the top of the graphic. In this study it was noted that a prescription statement and a process statement have very similar effect, that is, the direction to a participant to undertake a specific action. With the prescriptive regulatory statement, the detail of the action required is held within the statement whereas for a process regulatory statement the action (nominated as process:party-plan or process:authority) is located outside that statement. This close association is reflected in **Figure 2**, considering the ranking of jurisdictions in the spectrum from performance to prescription.

Alberta and British Columbia have 100% prescription/process regulatory statements whereas Brazil and New South Wales have the greatest proportion of outcome-based regulatory statements (principle/performance) with 13% and 11% respectively. The Alberta Energy Regulator's *Hydraulic Fracturing – Subsurface Integrity* Directive[5] shows a significant proportion of process regulatory statements, principally invoking elements of parallel Directives it has issued for related items. Other agencies invoke codes and standards from internationally recognised authorities, external to governments, such as the American Petroleum Institute[6]. It is notable that those jurisdictions with the highest proportion of performance/principle-based regulatory statements (Brazil, New South Wales, Western Australia, South Africa and South Australia) have virtually no unconventional resource development whereas the remainder, except for Illinois[7], have high levels of unconventional resource development and lower proportions of performance/principle-based regulatory statements, consistent with observations given in **Table 2** (May 2007). The data provided in **Table 6** and **Figure 2** indicates that there is rare use of principle and performance based

[5] https://www.aer.ca/documents/directives/Directive083.pdf
[6] http://www.api.org/products-and-services/standards, 25/01/2018
[7] Illinois has a reasonable conventional oil and gas sector but the development of shale resources started to decline with reduced East Coast gas prices limiting the establishment of a new resource play. In this case the legislation came first, rather than catch-up. It has yet to evolve. The hydraulic fracturing legislation is, however, comprehensive but the gas price remains low, limiting the attraction of new field development.

regulation in the US, this concurs with observations by *Resources for the Future* (Richardson et al. 2013).

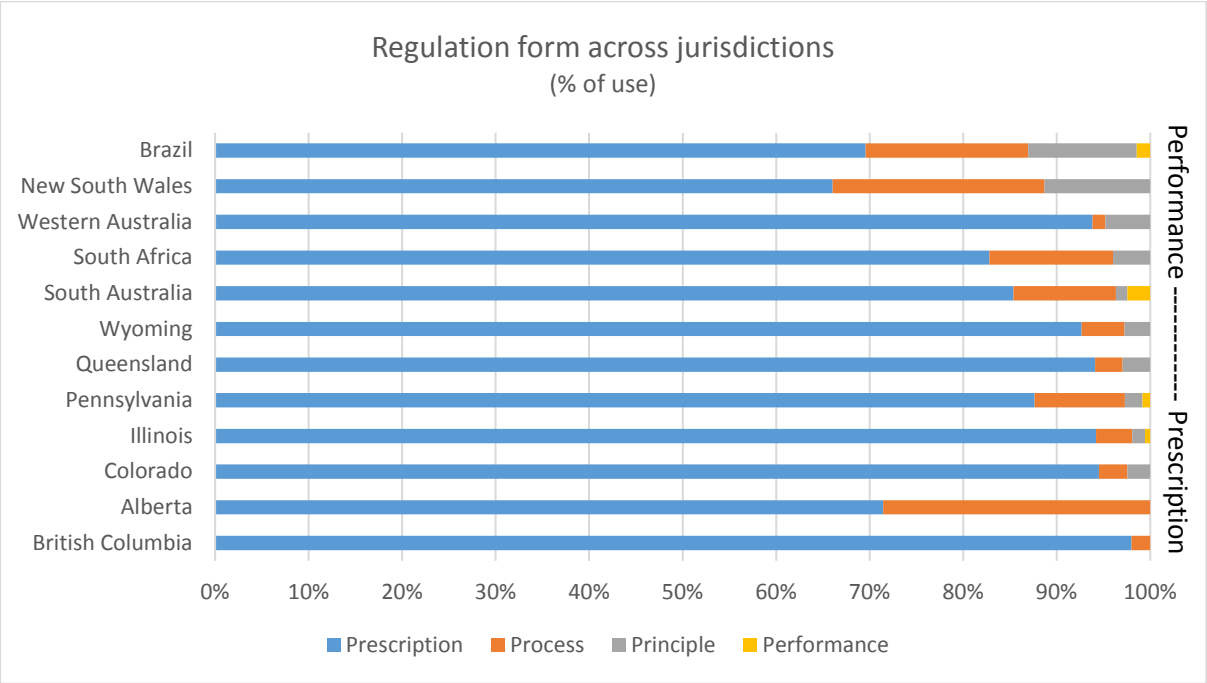

Figure 2 Regulation form across jurisdictions (% use for each form)

(12) **Regulatory form summary. Figure 3** shows the distribution of each form of regulatory statement form discovered across the entire dataset. The predominant form are the prescriptive statements, sub-forms action (21%), evidence/discovery/notification (19%), power (18%) specification (14%), collectively accounting for 72% of all regulatory statements. All process statements account for 8.2%, principle for 2.8% and performance for just 0.5%. Hence, the use of performance regulation is rare at a total of 3.3%. The less frequently used prescriptive statements were identified as prohibition 4.7%, responsibility 3.8%, mandate 3.6%, liability/defence 2.9% and exemption 1.5% were, in the majority of aspects, significantly more represented than the use of principle and performance.

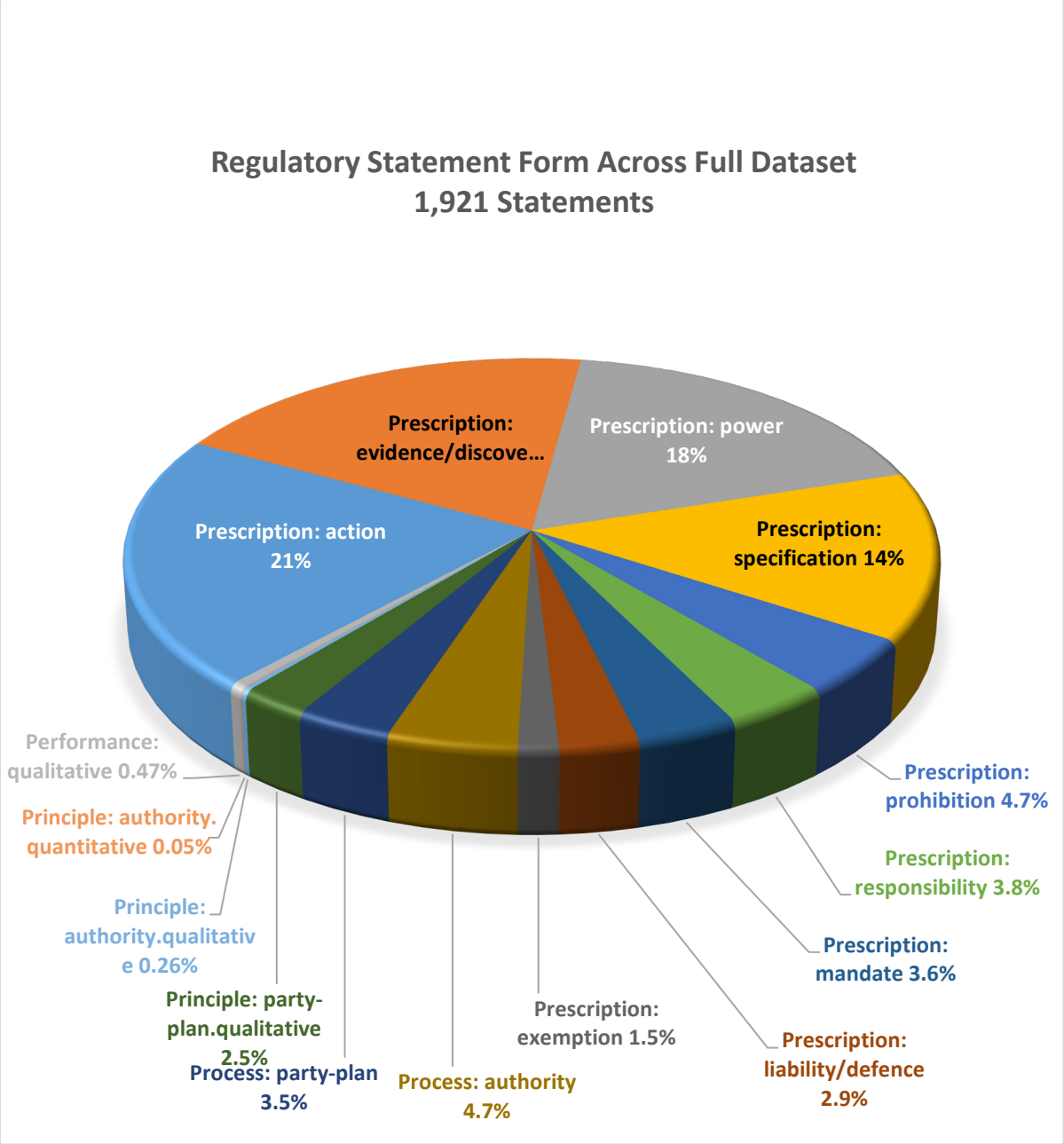

Figure 3: Distribution of regulatory form across the full data set

(13) **The influence of regulatory form over unconventional resource development.** Data describing the history and degree of development of selected jurisdictions are shown in **Table 7.** Also provided is the proportion of prescription/process regulation that prevails in those jurisdictions. The major unconventional oil and gas producing states/provinces of Alberta, British Columbia, Colorado, Pennsylvania and Wyoming show a mean application of 98.4% prescription regulation with a total of 38,045 active wells at time of survey. The 6 jurisdictions at the bottom of the Table have a precription level of 93.5% with only 11 wells between them fractured under current regulatory codes. Queensland has a modest number of fractured wells and 97% prescription. The data is shown in **Figure 1 (repeat)** together with operator numbers. Note that well count in the figure is on a logarithmic scale.

Table 7: Hydraulic fractured well and use of prescription/process regulation

Jurisdiction	Specific unconventional regulation	Unconventional resource history	Hydraulically fractured wells	Percentage regulation prescription/process
Over 1,000 unconventional wells				
Alberta	Yes	15 years	7,700	100%
British Columbia	No	14 years	4,400	100%
Colorado	No	27 years	18,168	98%
Pennsylvania	Yes	12 years	6,651	97%
Wyoming	No	31 years	1,126	97%
			Mean	98.4%
Less than 1,000 unconventional wells				
Queensland	No	21 years	425	97%
New South[8]	Yes	17 years	61	89%
Western	No	No	7	95%
South Australia	No	5 years	4	96%
Illinois	Yes	No	0	98%
Brazil	Yes	No	0	87%
South Africa	Yes	No	0	96%
			Mean	94%

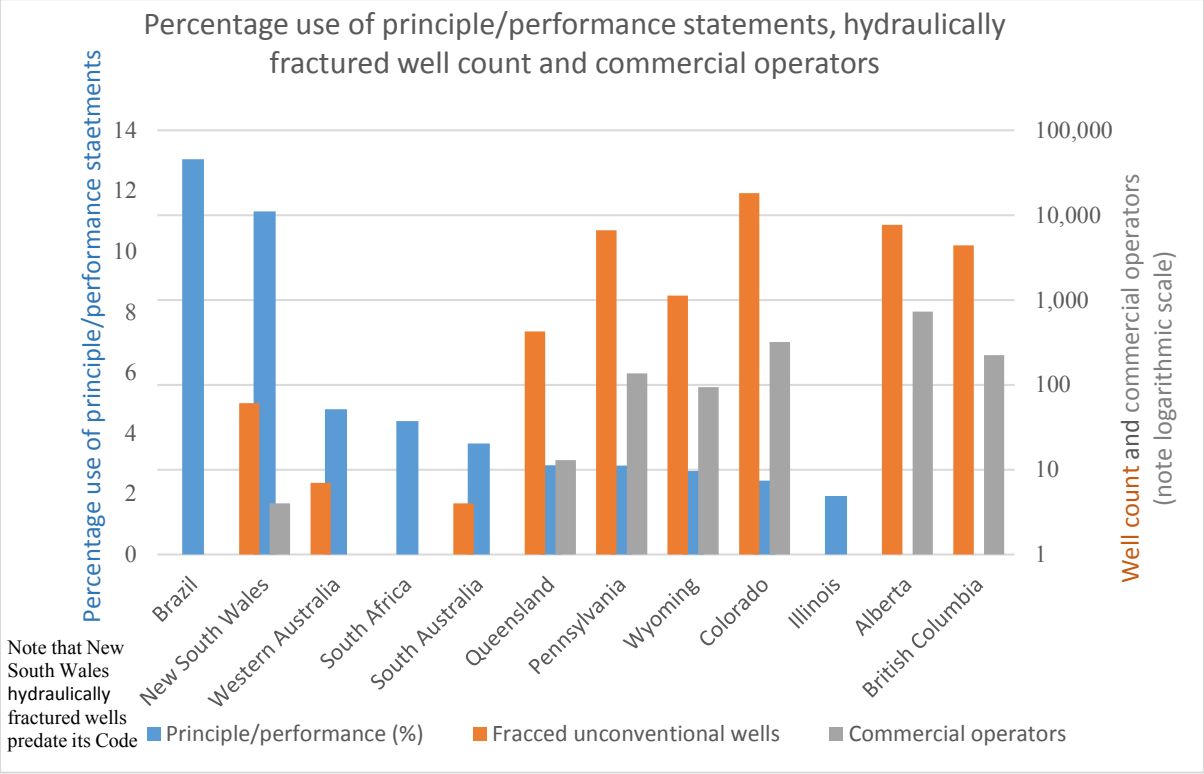

Figure 1 (repeat): Unconventional well development and use of performance regulation

[8] The wells described as having been hydraulically fractured in NSW were fractured before the present codes came into effect. No wells have been fractured under the current regime in NSW.

(14) **Summary.** Within the context of regulation applied to hydraulic fracturing, it would appear that prescriptive regulation is strongly associated with commercial scale development of the unconventional (shale oil and gas and coal seam gas). Prescriptive regulatory regimes are implemented by regulators with strong technical capacity, the staff having a high proportion of engineers and geologists[9] and lawyers largely restricted to compliance matters.

(15) The preceeding discussion referring to regulatory form has its real value in 'mindfully' designing regulation, fully aware of what is being sought to be achieved and how best to do that. The absence of a regulatory form typology has not helped law drafters and it became clear during the course of this research, that an unambiguous typology would be a significant benefit to ehance the development of clear regulation. Policy papers authored (Black 2010, Bridgman and Davis 2000, Freiberg 2010, Gunningham 2017) in Australia have contributed to good regulation but have yet to take the steps of providing that clarity of the output measure encompassed by this regulatory typology.

(16) Compliance. My research into hydraulic fracturing regulation attempted to establish the compliance regime of each jurisdiction but data shortages and definitional differences resulted in an inability to cast light on the area. **Table 8** shows some of the problems.

Table 8: Incident data availability

Jurisdiction	Hydraulically fractured wells	Public datasets	Unconventional resource identified in dataset
Colorado	18,168	Query database	Yes
Alberta	7,700	CSV files	Not directly
Pennsylvania	6,651	Query database	Yes
British Columbia	4,400	Query database	Not directly
Wyoming	1,126	Excel database	Yes
Queensland	425	No[10]	
New South Wales	61	Not found	
Western Australia	7	Incident data is not released[11]	
South Australia	4	Detailed annual report	Yes
Brazil	0	Insufficient resource	
Illinois	0	Not found	
South Africa	0	Insufficient resource	N/A

Agencies in the US and Canada have very high levels of public reporting and the databases are very comprehensive allowing a query to examine drilling reports, old files, inspectors reports and incident data, mostly in near real time. Except for some material in South Australia, these matters are completely hidden in Australian States or they are held in such a way as to be meaningless and not provide for any real time learning.

[9] The observation is made having visited a number of oil and gas and environmental agencies (both Federal and state) in the US including Pennsylvania, West Virginia, Virginia, Texas, Wyoming, Montana, Colorado, Louisiana, Alabama and Washington, DC.

[10] Department of Natural Resources, Mines & Energy advise no datasets are maintained, Personal Communication, January 2019

[11] Department of Mines, Industry Regulation and Safety does not release information on incidents regarding oil and gas activities. Personal communication, Jacqui Middleton, Resource and Compliance Division, January 2019

(17) Definitions and thresholds. Despite the availability of data indicated in **Table 8**, cross jurisdictional difficulties in legal definitions and thresholds precluded direct comparison of incidents. However, a team of academics (Patterson et al. 2017) in the US assembled spills data from four states: Colorado, North Dakota, Pennsylvania and New Mexico that reported nearly 6,700 events over the period 2005 to 2014 an is shown in **Table 9**.

Table 9: Unconventional spills summary counts 2005-2014

Pathway Group	Colorado (CO)	North Dakota (ND)	Pennsylvania (PA)	New Mexico (NM)
Blowout	8	75	4	8
Equipment	34	797	14	62
Flowlines	92	1,146	61	94
Processes	37	25	66	10
Storage	171	1,106	627	152
Transportation	66	377	61	26
Wellhead	55	67	39	59
Unknown	15	860	465	15
Total spill events	475	4,453	1,337	426
Unconventional well years 2005-2014	41,749	36,486	39,983	13,558

This information moves toward identifying the occurrence of systemic issues, further causative data was needed to start to extract true value shown in the detail of **Table 10**.

Table 10: Causes of blowouts 2005-2014

Blowout	Environmental conditions	Equipment failure	Human error	Unknown	Blowout rate per well year
Colorado	1	4	2	1	0.0002
New Mexico		2	2	4	0.0006
North Dakota		2	1	72	0.0021
Pennsylvania		1		3	0.0001

This data is now at a granular level able to highlight system issues with the observation that blowouts in North Dakota are occurring at a disproportionate rate compared to the other major petroleum producing states. Further analysis of the information trying to relate the North Dakota anomaly to regulatory form suggested that regulatory form was not a contributory factor as shown by the distribution of regulations from each jurisdiction across

the spectrum shown in **Figure 4**, with none of the North Dakota statements unusually distributed or at a disproportionate representation.

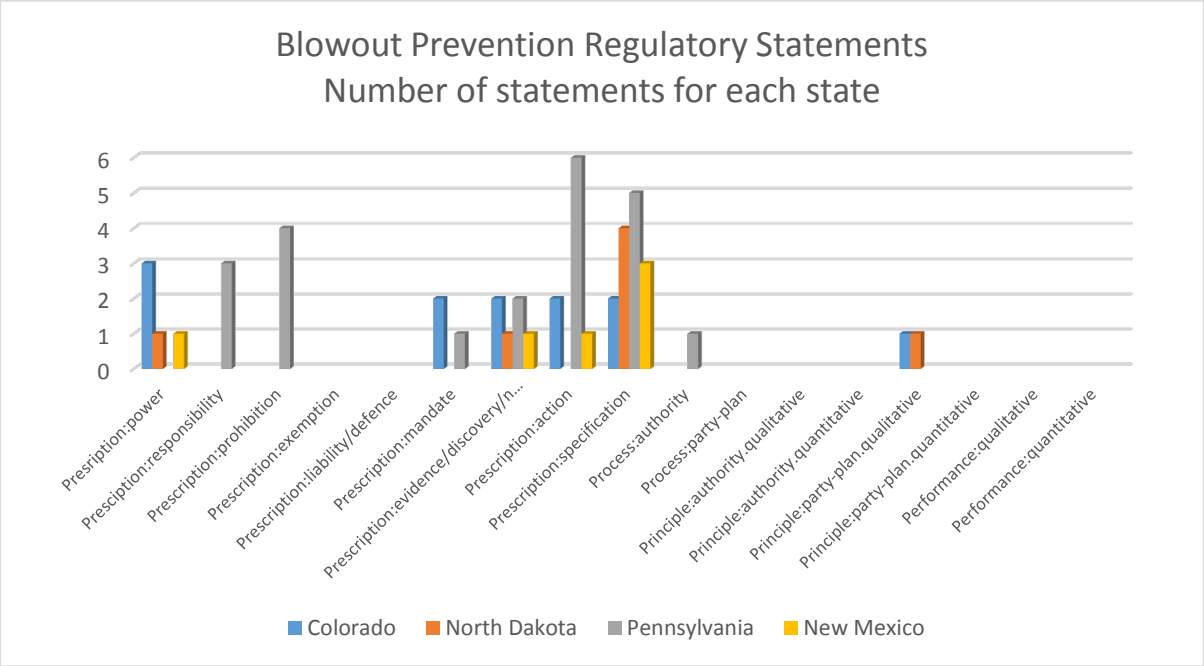

Figure 4: Blowout prevention regulatory statement form for Colorado, North Dakota, Pennsylvania and New Mexico

(18) **Compliance regime of the Texas Railroad Commission[12].** The Railroad Commission[13] is headed by three elected members, and is responsible for administration of services in Texas including petroleum on state and private lands. Texas has millions of petroleum wells and has seen huge development over the last twenty years with unconventional resources producing oil and gas within the con-urban areas of Dallas-Fort Worth and in rural areas as shown in **Figure 5**.

[12] Personal communication, Leslie Savage, PG, Assistant Director Technical Permitting, Texas Railroad Commission, 2016.
[13] https://www.rrc.state.tx.us/oil-gas/

Figure 5: The Permian Basin, West Texas, oil wells left to right in foreground and gas at lower right and centre rear.

(19) Compliance action by Texas Railroad Commission. Given the scale of well development in Texas, compliance monitoring is surprisingly rapid and efficient. Officers are based in the field offices and spend most of their time in the field. Data is now being assembled within digital frameworks whereas it used to be paper based and only in the regional offices. **Table 11** shows recent compliance data for the state of Texas. The information is updated very frequently[14]. The detail provided by the Commission and the currency of data gives a real-time picture of oil and gas operations such that the public, investors and the sector understand the performance of the industry today, the 27th November 2019 and any other day. No such information is available in Australia.

[14] This data had been updated on the day it was sourced.

Table 11: Texas oil and gas operations compliance report at 27/11/2019

Report on Oil and Gas Field Operations' Violations and Enforcement					
Oil and Gas Field Operations Data	FY19/Q 1	FY19/Q 2	FY19/Q 3	FY19/Q 4	FY19 Total
Number of oil and gas inspections performed	33.611	27,803	34,384	37,389	133,187
Number of oil and gas facility inspections with no violation	30,539	25,065	31,126	34,206	120,936
Number of state-wide rule violations	5,524	5,027	5,610	5,645	21,806
Number of major state-wide rule violations	13	16	11	14	54
Number of oil and gas complaints received	113	98	163	127	501
Number of oil and gas complaints resolved	97	91	135	99	422
Number of pipeline severances/seal orders issued	2,606	6,173	3,135	2,443	14,357
Number of district-initiated issuance of severance/seal orders	116	76	98	118	408
Number of alleged oil and gas violations sent to Office of General Counsel Legal Enforcement	433	366	470	349	1,618
Oil and Gas Field Operations Violation by Rule					
3.1: Organization Report; Retention of Records; Notice Requirements	1	0	0	0	1
3.2: Commission Access to Properties	8	7	2	1	18
3.3: Identification of Properties, Wells, and Tanks	87	109	105	63	364
3.5: Application To Drill, Deepen, Re-enter, or Plug Back	3	2	1	0	6
3.8: Water Protection	65	64	85	59	273
3.9: Disposal Wells	1	0	1	1	3
3.13: Casing, Cementing, Drilling, and Completion Requirements	28	23	21	17	89
3.14: Plugging	178	118	101	152	549
3.15: Surface Equipment Removal Requirements and Inactive Wells	0	1	5	1	7
3.16: Log and Completion or Plugging Report	15	4	2	8	29
3.17: Pressure on Braden-head	5	6	3	6	20
3.20: Notification of Fire Breaks, Leaks, or Blow-outs	2	6	1	0	9
3.21: Fire Prevention and Swabbing	14	5	3	6	28
3.22: Protection of Birds	5	1	0	0	6
3.26: Separating Devices, Tanks and Surface Commingling of Oil	1	0	0	0	1
3.27: Gas To Be Measured and Surface Commingling of Gas	0	0	0	0	0
3.32: Gas Well Gas and Casing-head Gas Shall Be Utilized for Legal Purposes	0	0	0	0	0
3.36: Oil, Gas, or Geothermal Resource Operation in Hydrogen Sulfide Areas	2	1	2	0	7
3.46: Fluid Injection into Productive Reservoirs	10	1	2	0	30
3.57 Reclaiming Tank Bottoms, Other Hydrocarbon Wastes, and Other Waste Materials	1	0	0	2	1
3.58: Certificate of Compliance and Transportation Authority; Operator Reports	0	0	0	17	0
3.73: Pipeline Connection; Cancellation of Certificate of Compliance; Severance	4	6	5	0	29
3.81: Brine Mining Injection Wells	0	1	0	0	1
3.91: Clean-up of Soil Contaminated by a Crude Oil Spill	0	0	0	14	0
3.96 Underground Gas Storage	0	0	0	0	0

Report on Oil and Gas Field Operations' Violations and Enforcement					
Oil and Gas Field Operations Data	FY19/Q 1	FY19/Q 2	FY19/Q 3	FY19/Q 4	FY19 Total
3.98: Standards for Management of Hazardous Oil and Gas Waste	1	0	0	0	1
3.99 Cathodic Protection Well	0	1	0	0	1
3.106 Sour Gas Pipeline Facility Construction Permit	0	2	0	0	2
4.611: Oil and Gas NORM Prohibited Disposal	0	0	0	0	0
TNRC 85.3855: Administrative Penalty	0	0	0	0	0
TNRC 91.143: False Applications, Reports, and Documents and Tampering with Gauges	2	8	131	0	143
Oil and Gas Enforcement					
Number of oil and gas enforcement dockets	59	71	47	50	227
Number of repeat oil and gas violators based on a seven-year look back of docketed cases	19	30	16	22	87
Amount of final oil and gas enforcement penalties assessed	$695,609	$1,274,658	$625,104	$685,871	$3,281,242

(20) Severance/Seal Orders. One powerful tool available to the Railroad Commission is that of the severance and seal order where, due to the identification of serious violation on that well, it is suspended and sealed such that transferrance or sale of product from the well is prohibited. The faults must be corrected prior to unsealing the well and any benefits from production are permitted. The use of severance/seal orders are able to be imposed with very little cost to the agency as opposed to the long, tedious and expensive process of engaging in legal compliance actions.

(21) Summary – Compliance. In order for the public, regulators, the resources sector, neighbours and interest groups to not be subject to information assymetry (ie. ignorance of the facts) a rapid, detailed reporting system is required that operates outside of any political influence and draws together all relevant data from field operations. The US examples set a reasonable benchmark although there are many areas that could improve information quality and allow interjurisdictional comparisons. The current levels of secrecy and information obfuscation impedes satisfactory resource development and consequential uptake of improved engineering practice, environmental protection and social cohesion.

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